H.C. SRIVASTAVA

MEDICINAL AND AROMATIC PLANTS

भाकृअनुप
ICAR

Indian Council of Agricultural Research
New Delhi

Medicinal and Aromatic Plants

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Preface

Nowadays there is global interest and expanding market of plant based raw materials for manufacture of drugs, pharmaceuticals, perfumery products, cosmetics and aroma compounds used in food flavours and fragrances. This demand in organized sector of industry has led to their introduction into agriculture which beside meeting the demand at reasonable price, has also enabled the producer to maintain standards on quality, potency and chemical composition of the farm produce. A large number of medicinal and aromatic plants have thus come under systematic research efforts through multi-disciplinary investigation in India in the last three decades. This has generated a wealth of valuable information on several facets of agricultural productivity like genetics and crop improvement, crop production and chemical composition including faster instrumental analytical methods to keep pace with the continuously updated standard laid out by user industry. This material is largely scattered in research journals, proceedings of seminars and symposia and technology papers. I have made an effort to bring all this information together in a technical bulletin.

It presents an integrated account of contemporary status of agricultural research and production technology for profitable cultivation of forty-one medicinal and aromatic crops as commercial crop in India.

I believe that this technical bulletin will serve as a comprehensive information on cultivation of industrial crops for growers, entrepreneurs, researchers, students and user industries.

The medicinal and aromatic plants in India, hitherto are grown by marginal farmers with low input in resources resulting in a wide gap between yield recorded in research farms and individual growers. This book will primarily serve these growers to raise their crop yield.

My objective extends further to reach elite growers and corporate entrepreneurs with a promise of sustained high yields. Key references on each crop have been cited to assist inquisitive entrepreneurs and through this process have sought to project the work of Indian scientists as referral material to outside world.

H.C. Srivastava

Contents

MEDICINAL PLANTS

Aloe

(*Aloe vera* Linn. Syn. *Aloe barbadensis* Mill.)

Aloe is also called Gheekanvar. Its family is Liliaceae.

Origin and distribution

It originated in Africa and Mediterranean countries such as Greece and southern Italy. It is also found distributed widely in Egypt, Greece, Italy, Africa, USA, Europe, Cyprus, Malta, Sicily, Canary Cape, Cape Verde and naturalized over arid tracts all over India (Farooqui and Sreeramu, 2001). The plant also grows in Philippines, south east Asia including Malaysia, Tahiti, Japan and Hawai. Also in China and West Indies aloe is found distributed (Anonymous, 1983).

Description of plant: It is a small, stem-less, herbaceous, perennial plant with good root system. Leaves are lanceolate, sharp pointed, jagged edged,

Aloe

thick, fleshy and grows directly from ground in form of large rossete. The base of the leaf is round with broad and flat upper surface. The fully-grown mature leaves are greyish green to dirty white in colour. In certain types leaf lamina has white streaks. Flowering stalk is erect, which is not branched. It bears bright yellow flowers, which are arranged in axillary spike. The flower is actinomorphic, perianth, arranged in two whorls of 3 petals each (Atal and Kapur, 1982). It has 6 stamens in two whorls, the inner filaments are shorter than those of the outer whorl. Ovary is superior, trilocular and has axile placentation. In India out of 275 only 4 species are found of which *Aloe vera* Linn. (Syn. *Aloe barbadensis* Mill.) is most widely naturalized.

Genetics and breeding

Studies on *Aloe vera* (Syn. *Aloe barbadensis*) showed that the somatic chromosome number is 2n=14. A triploid plant (2n=21) has been reported from Kanyakumari by Abraham and Nagendra Prasad (1979). Ramaswami Ayangar and Sampatha Kumar (1976) carried out karyological studies of three varieties found in India and came to a conclusion that some elimination in chromatin content in the species was possibly the main method in the evolution of these distinctive cytotypes in nature.

At Indian Institute of Horticultural Research, Bengaluru a research project on evaluation of genetic diversity of *Aloe vera* for development of superior variety is underway since 2002 (Srivastava and Vasanth Kumar, 2002). Varieties should be developed to get more barbaloin yield and more yield of mucilage having resistance to diseases and pests.

Varieties

The National Bureau of Plant Genetic Resources, Delhi has identified EC 111267, 111269, 11127, 111279, 111280 and 111281 which are reported to have more aloe. Other than the mentioned strains some other strains with more pulp have been found, i.e. EC 111266, 111272, and 111277. Work on varietal improvements is also being done at Indian Institute of Horticultural Research, Bengaluru (Srivastava and Kumar, 2002). The spotted leaved *Aloe vera* is found in Maharashtra. The leaves are comparatively greener, larger and are dentate.

Chemical constitution

The pharmacopoeia recognizes aloe drug Curacao aloe – obtained from *Aloe barbadensis* (Syn. *Aloe vera*). Its major chemical compounds are barbaloin and isobarbaloin. B. aloin is the principal active constituent of aloe, which is a mixture of glycosides. Some other chemical constituents are aloe-emodin, aloetic acid, homonataloin, olesin, aloesome, emodin, chrysamminic acid, chrysophanic acid, apoise, galacturonic acid, calcium oxalate, choline, choline

salicylate, saponins, uronic acid, amylase etc. The main constituent of all varieties of *Aloe vera* is the crystalline substance barbaloin.

Parts used: Leaf, pulp and juice.

Medicinal uses

- According to Nikta Shah, 2002 it is used as skin tonic in cosmetic industry.
- The Aloe gel gives cooling effect and also acts as a moisturizing agent.
- It also has role in gerontology and rejuvenation of aging skin. According to Anon. (1983) this property of Aloe is because of its biogenic material.
- Plant is anthelmintic, aperient, carminative, deobstruent, depurative, diuretic, stomachic and emmenagogue.
- Juice is used in skin care medicines, dyspepsia, amenorrhoea, burns, hyperadenosis, hepatopathy, splenopathy, constipation, spanomenorrhea, abdominal tumours, dropsy, carbuncles, sciatica, lumbago and flatulence.
- The elio, a product made by juice of this plant, is used for helminthiasis in children and is a purgative, anthelmintic and emmenagogue. It is used for treatment of painful inflammations, and chronic ulcers.
- Liquid *Aloe vera* is used as drink. It is an intestine regulator. It has several vitamins and minerals.
- It improves arthritis and rheumatic pains.
- It improves blood and lymphatic circulation.
- It improves liver function and recommended as preventive of cirrhosis
- It is used for treatment of seborrhea, herpis, psoriasis, eczema and mycosis.
- It diminishes wrinkles, cures acne, skin irritation, sun burn and reduces inflammation.
- It accelerates removal of dead skin and renews growth of skin cells.
- *Aloe vera* is used in lotions, creams, shampoos, soaps, lipsticks, moisturizers etc.

Cultivation technology

Root suckers or rhizome cuttings is used to propagate this plant. The plant can be cultivated in dry climatic conditions in poor soils without much care (Bentely and Trimen, 1992). It can be grown on variety of soil, though it does well on the sandy and loamy soils with pH 8.5. The plants prefer warm but can thrive in humid climate also. The root system of this plant is shallow and does not penetrate deep into the soil. A mixture of 150 kg/ha nitrogen, potassium and phosphorus should be mixed up in soil near the root system gently. Since the plant is not water loving, water should not be allowed to lodge.

Under irrigation *Aloe vera* is usually cultivated between March and June. Before cultivation land is ploughed twice and is cleaned. About 25 tonnes/ha of farmyard manure is added. The plants are planted at a spacing of 60 × 30 cm or 60 × 45 cm. About 15-18 cm long root suckers or rhizome cuttings are planted in such a way that two-thirds portion of the root- sucker or rhizome cutting should remain under the ground. Interculture, weeding, irrigation, plant protection should be attended.

Plant protection

The plant is not found to be attacked by pest and diseases. However in India, it has been reported that sometimes *Alternaria alternata* and *Fusarium solani* causes leaf spot diseases, which can be controlled by spraying proper fungicide.

Harvesting

The harvesting is done after 8 months of planting. At the time of harvesting the plants are either removed manually or can also be removed with the help of tractor drawn disc harrow or cultivator. The broken rhizomes may result in a new plant in succeeding years.

Yield

The commercial yield of plant starts from second year to five years of age. The yield of the leaves on a fresh weight basis is around 10,000 – 12,000 kg/ha (Singh *et al.* 1995).

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Periwinkle

[*Catharanthus roseus* (L.) G. Don. Syn. *Vinca rosea* Linn.]

Periwinkle (Family Apocyanaceae) is also called Sadabahar, Sada Phuli, Nayantara.

Origin and distribution

Origin of the plant is from West Indies and Madagascar. It is distributed mainly in India, China, Indonesia, Israel, Madagascar, Philippines, South Africa, and USA. In India it is extensively cultivated in the states of Tamil Nadu, Karnataka, Gujarat, Madhya Pradesh and Asom. Uttarakhand like low temperature (winter) adversely affects its cultivation.

Description of plant

It is erect, perennial herb. It is highly branched and attains the height of

Sadabahar

about 100 cm. The leaves are oblong or obviate, opposite, short petiolated, smooth with entire margin. The lower surface of leaf is light green coloured with prominent veins. Flowers are normally pink, pink eyed or white coloured. However Namdhari & Sons (a seed company in Bengaluru) sells *Vinca rosea* of various interesting colours. Flowers are borne on axils in pair. The calyx is linear-subulate. The corolla tube is cylindrical measuring about 30 mm in length. Anthers are epipetalous present on a short filament. The bicarpellate ovary is basally distinct with fused common style and stigma, which is ascribed to post genital carpel fusion (Walker, 1975). The fruit is dehiscent, it consists of a pair of follicles containing upto 30 linearly arranged seeds with a thin black tegumen.

Genetics and breeding

Haploid chromosomal number of periwinkle was given as n = 8 by Furusato (1943). Flory (1944) suggested the presence of two complementary genes for flower colour, i.e. 'R' & 'W'. Genotypes carrying dominant allels 'R' & 'W' bears pink flower, only 'R' pink eyed (oscillatus) flowers and recessive alleles, i.e. 'rr' white flower. For induction of autotetraploid using seeds as well as single nodes Krishnan (1995) studied the response of chromosome doubling to morphological characters, yield and total root alkaloid content. Singh *et al.* (1992) studied 27 germplasms and reported variation in air dried leaf and root yield from 1067.67 to 3793 and 124.37 to 578.67 kg/ha respectively. Varieties should be developed for higher yield of vincristine and vinblastin, ajmalcine and serpentine and resistance to diseases and pests.

Varieties

(i) Nirmal: This variety of *Catharanthus roseus* was developed by the Central Institute of Medicinal and Aromatic Plants, Lucknow. It is found to possess field resistance to die-back and collar rot diseases.

(ii) At Indian Institute of Horticultural Research, Bengaluru Dr. R. Krishnan (1995) developed the strains M-153 and L-31, which were identified with high total alkaloid content in roots. Root diameter was identified as a character for selection of high root yielding plants. These two lines were tested in All India Crop Research Project. Their roots contained about 3% of total alkaloids.

(iii) Prabhat was released in 2002 by AICRP on Medicinal and Aromatic Plants; CCS Haryana Agricultural University, Hisar.

Chemical constitution

This plant has largest number of alkaloids in the plant kingdom (Hui-Lin Li and Willaman 1972). Constable *et al.* (1981) and Balsevich *et al.* (1988) detected 60 alkaloids from leaves by means of supercritical fluid

chromatography and mass spectrometry. Most important are Vincristine and Vinblastin. Root is found to have ajmalcine and serpentine. Four alkaloids possessing antibacterial activities are extracted from leaves. Moreover there are also two glycosidal principles, urosolic acid, leurosine, isoleurosine, previne, mitaphylline, lochnevin and perosine (Chatterjee, 2000).

Parts used: Whole plant is used for medicinal purpose.

Medicinal uses

- Root alkaloids Ajmalcine and Serpentine are used for allopathic medicines for cure of hypertension and other diseases.
- Leaf alkaloids Vincristine and Vinblastin are used in allopathic medicine to treat blood cancer.
- Leaves are used for curing diabetes, menorrhagia and wasp stings.
- Roots are used as tonic, for stomach ache, sedative and tranquilizer.
- There was a discovery of anti-neoplastic activities of a leaf alkaloid by Nobel *et al.* (1958).
- Insect sterilants have been identified from Periwinkle

(Sukumar and Osmani, 1981 and Deshpande *et al.* 1988). Patel *et al.* (1987) and Deshpande *et al.* (1988) have reported about its inhibiting properties towards insect growth and development.

Cultivation technology

Periwinkle is sensitive to lower temperature and also it does not grow well in water logged or high alkaline soils. Otherwise it can be cultivated in variety of soil. The seeds collected by harvesting are soon sown since they are viable for short period.

The seed may be sown either directly or may be raised in nursery. Vegetative propagation of the plant is also possible. In case of direct sowing 2.5 kg of seeds/ha are sown. Later, thinning is done to maintain the distance to 45 × 45 cm. But in case of nursery 500 g of seeds are used/ha. After 10 days, the seeds germinate and after 60 days the plant becomes ready for transplantation. For transplanting Dahatonde (1985) reported 30 × 30 cm as an optimum spacing for all the three coloured flower plants, i.e. pink, white and pink eyed. But experience show that 45 × 45 cm spacing is ideal for the crop. Seed germination and growth of seedling was found to be good in sandy soil following treatment with liquid cowdung (Karnick, 1977). Bharath Kumar *et al.* (1985) reported higher seed germination when the pre-soaking of seed was done and the farm yard manure (FYM) and soil mixture was used as the medium for germination.

In vegetative propagation, the cutting of about 10–15 cm length, with 5–6 nodes of softwood or hard-wood or semi-hard wood from lateral shoots are considered ideal. Although the softwood cutting is considered to be better

than the hard or semi-hard wood cuttings. The percentage of rooting is 90% if the cuttings are soaked in NAA solution of 50 ppm concentration for a night.

Plant protection

- Dieback disease or Twig blight caused by *Pythium butleri, Phytophthora nicotianae, Pythium debaryanum, Alternaria tenuissima* and *Colletotrichium dematium.* They are checked by spraying Dithane Z-78 at an interval of 10–15 days.
- Little Leaf disease due to mycoplasma sometimes occurs and can be controlled by uprooting and destroying the affected plants.

Harvesting is done when yield and alkaloid content becomes optimum. According to Karnick (1977) three growth phases exist, ie. Pre-flowering having 1.51% of root alkaloid; flowering having 2.57% of root alkaloid; and post-fruiting having 1.37% of root alkaloids. Therefore, flowering period was recommended for collection of roots with high alkaloid content. Many other reports for harvesting have been given, by which it is proven that in south India, where winter is mild and short the harvesting of crop for roots is done after six months of plantation. According to Farooqui and Sreeramu (2001) the crop is harvested after 12 months of sowing for roots. According to them in case of the demand of leaves, two strippings can be done. The first is done after 6 months and second after 9 months of sowing; also the third leaf stripping can be obtained when whole plant is harvested.

Yield has been reported by Khan (1977) as 3.6 tonnes of air dried leaves (cumulative of three harvests at 6, 9 and 12 months) and 1.5 tonnes of air dried root/ha. He also suggested that under large scale cultivation about 50% of yield can be expected. Vitkare and Phadnawis (1988) reported dry root yield 660 kg/ha and the total alkaloid content 2.6% under Akola conditions. Hegde (1988) reported 800 kg/ha of root yield and 1800 kg/ha of leaves yield.

Processing

Roots are dug out carefully, washed in water and dried in sun and stored at room temperature. Leaves are harvested, collected and dried under shade then are stored at room temperature. Flowers are picked, shade dried and stored at room temperature.

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Honey Plant

(*Ammi majus* Linn.)

Honey plant (Umbelliferae) is also called Madhugid.

Origin and distribution

It originated in Egypt and grew in the Nile Valley especially Behira and Fayoom. It is found distributed in the basin of Mediterranean sea in Syria and Palestine. It is also found in some regions of Iran and the mountains of Kohaz (Ramadan, 1982). It is found wildly in Abbottabad, Mianwali, Mahran, Lahore and also in Europe, West Africa and Abyssinia. In India it is cultivated on an experimental scale in the places like Uttar Pradesh, Gujarat and Tamil Nadu. In India with the courtesy of UNESCO in 1955, 2 species, i.e. *Ammi majus* and *Ammi visnaga* were introduced in the Forest Research Institute, Dehradun, Uttarakhand.

Honey Plant

Description of plant

It is an annual herb of 0.80 to 1.2 m height. The plant stem is erect and solid. The leaves are compound, light green, alternate, pinnately divided having lanceolate to oval segments. The plant has axillary and terminal compound umbels of white flowers. The fruits are ribbed, ellipsoid, green or greenish brown when immature, but turn to reddish brown at maturity. The seed tastes bitter and extremely pungent. Its odour is characteristically terebinthinate, which becomes strong on crushing. The plant has a long tap root. Two varieties are found, ie *Ammi majus* L. var. Sutton's Monica and *Ammi majus* L var. Horticulture.

Genetics and Breeding

Ammi majus L. was found to have 2n=22 chromosomes. The varieties are phenotypically different just because there is difference in the secondary constriction (Hore, 1979). Breeding should be done to develop high yielding varieties resistant to biotic and abiotic stress.

Variety

Researches should be done to improve the variety yielding high amount of seeds and producing high percentage of xanthotoxin. In addition to it, the variety should have resistance to diseases and pests in field and during storage so that the xanthotoxin amount is not reduced.

Chemical constitution

Fahmy and Abu-shady in 1947 isolated ammoidin. It was reported to have xanthotoxin, bergapten isopimpinellin, isoimperatorin, oxypeucedanin, heraclenin, oxypeucedanin hydrate, This species is one of the richest known sources of linear furocoumarins. This furocoumarins when activated by sunlight acts as bactericidal, fungicidal, mollscicidal, larvicidal, nematicidal, insecticidal, ovicidal and viricidal, so it is considered as a natural pesticide. The fruit contains 1% of amorphous glucosidal principle, 0.45% tannin, 4.76% oleoresinous products, 3.2% of an acrid oily liquid, 12.92% fixed oil, 0.2% glucose, 13.83% proteins and 22.43% cellulose (Fahmy and Abu-Shady, 1947).

Parts used: Flowers and fruits.

Medicinal uses

The yellowish brown powder of fruit is prepared for use in the treatment of leukoderma (vetilago). In Atharva Veda (1400 BC) it is known for treating vetilago. Also in 1982, the FDA (USA) approved it as a treatment of severe cutaneous psoriasis.

Cultivation technology

The plant can either be raised by sowing seeds or by growing in a nursery and then transplanting it. About 1.5–2 kg of seeds should be sown in one hectare of land. The most favorable time for sowing of seed in north India is between third week of October to first week of November. The seed sown later gives lower yield. After sowing, the seed is covered with thin layer of soil. The germination of seed occurs after 10-12 days of sowing. For planting the spacing of 45 cm × 60 cm is recommended. Requirements of interculture, irrigation and manuring are normal.

Plant protection

A disease is caused by the fungus *Aspergillus orchraceus*. Also some damage is caused by *Aspergillus niger*, *A. flavus* and *Fusarium oxysporum*. All these fungus are found to affect the xanthotoxin content and can be controlled by spraying proper fungicides.

Harvesting and thrashing

Harvesting of the crop is extended for a longer duration due to discontinuous maturation of fruiting umbels. If primary umbel matures and is not harvested soon, leads to the shedding of seeds. The shattering of seeds in this way in India is mainly responsible for the low yield. In the case where primary umbels matured and were harvested at an interval of two to four days, very good yield was assured. Therefore, it is believed that primary umbel and the early maturing secondary umbels are the major contributors towards good yield. (Ajit Singh, 1995).

The harvested crop is then stored for a couple of days and then, the seeds are thrashed. The collection of seeds in its green stage yields maximum amount of xanthotoxin from the fruits.

Yield

The average crop yield varies from 900 –1200 kg seed per hectare. The timely harvest ensures at least 25% increase in the yield.

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Ipecac

(*Cephaelis ipecacuanha* Brot A. Rich.
Syn: *Psychotria ipecacuanha* Stokes)

Ipecac (*Cephaelis ipecacuanha* (Brot.) A. Rich) of the family Rubiaceae is also called Ipecacuanha.

Distribution

Natural distribution of Ipecac is almost exclusively localized in the central American Tropical Forests (Bentely and Trimen, 1992). It is cultivated in Brazil, Malaya, Nicaragua and India. In India it is found in the foothills of Darjeeling, near Mungpoo, Rongo, Munsong and Latpanchor.

Description of plant

Ipecac is perennial, evergreen, herb growing upto 60 cm in height. The main stem is hard, branched, green when young and becomes brown when

Ipecac

mature. The plant is succulent at young stage. Leaves are rich green, simple, opposite, decussate, entire, ellipto-ovate, acute. Flowers are stipulate, interpetiolar, bilobed, lobes are imbricate and persistent. Inflorescence has cymose head. The flowers are interspread with involucres of bracts which are foliacious and arranged in two or more rows. The outer bracts are larger. The root is fully grown measuring 40–45 cm in length and in diameter 0.4 – 0.6 cm. It has a tap root system. Ipecac is a Portuguese name meaning "a creeping plant causing vomitting" (Hebis and Markiss, 1969).

Varieties

Varieties are:

- Rio: It is commercially known as Brazilian variety and grows in the moist, dense and tropical forests in Brazil.
- Cartagene: It is also known as Nicaraguan or Penamme variety growing in the dump and dark forests of Colombia, Nicaragua, Panama and Venezuela.

Chemical constitution

The principal alkaloid of Ipecac is Emitine. Some other alkaloids of Ipecac are Cephaeline, Psycotrine, O–methyl Psycotrine and Emetamin.

Parts used: Roots are the economic part of Ipecac. Stems and leaves are also used for alkaloid preparations.

Medicinal uses are:

- The Emitine is principally used for the treatment of amoebiosis; the dose is given as an injection of emetine hydrochloride. Its salt kills the *Entamoeba histolytica* (causal organism), particularly when it gets embedded in intestine.
- In large doses, it directly acts on the vomiting reflex center in the brain causing vomiting thus removing all the indigestible food from the stomach.
- Its small doses are used in cataracts, chronic bronchitis, asthmatic emphysema, tuberculosis and disorders of lungs and early stages of whooping cough.
- Now emetine hydrochloride is being pre-eminently used in cancer chemotherapy. Correct dosage of emetine hydrochloride can prove to be one of the safest therapeutics in certain types of cancer (Fisher, 1973).
- It is used for the preparation of tinctures.

Cultivation technology

Ipecac is sensitive to high as well as low temperature and is a shade loving

plant. The nursery beds are divided into the compartments of 2.7 m × 1.2 m under shade. The beds are built on slopy area to avoid water stagnation and usually raised 15 to 20 cm above the ground level. They require moist climate and temperature ranging from 18 to 38°C with the annual rainfall of 150 to 500 cm.

Propagation of plant can be done either by direct seed sowing or by vegetative method. Also it can be propagated through tissue culture.

(i) *By seed sowing:* The favorable season for seed sowing is middle of February to early March (Farooqui and Sreeramu, 2001). Before sowing the seeds are soaked in water for 24 hours. They are then sown in the raised seedbeds under artificially provided shade at the rate of 100 gm per bed of 2.7 m × 1.2 m. Proper care is required. Seed germination is effected by the factors like temperature, light, pH and moisture of the medium. The germination of seed is slow and takes 80–90 days, due to which the incidence of weed growth increases. For controlling the weeds and to facilitate the early germination mulching of beds with perforated black polyethylene sheets is generally practiced. Due to black polyethylene, the temperature as well as the moisture level increases, leading to the early germination of seeds. Most of the weeds get killed due to lack of light under black polyethylene sheets. The young growing plants are then transplanted into the main field at the spacing of about 15 × 15 cm and are then allowed to remain there for next three years.

(ii) *Vegetative propagation:* In this, the leaf or root cutting are rooted using soil and sand mixture in the ratio of 1: 3. Tissue culture is considered to be highly beneficial method since by this large number of plantlets are produced in short time. It is kept in shady place for two months and then transplanted in field.

Irrigation, interculture, organic manuring and plant protection are followed normally.

Plant protection

Ipecac plants are hardy. However two diseases are found to affect it, which are:

- *Leaf blight:* Caused by *Alternaria alternata* (Bharati *et al.* 1984)
- *Root Rot:* It is caused by *Fusarium* sp. Chetia and Baruah (1963) reported this type of wilting.

Harvesting is generally done in January–February. The roots should be dried in shade. Age of plant determines the amount of alkaloid extracted from it. About 0.5% of alkaloids extracted in six months of age and about 2.5% in three-years-old. Generally the plant is harvested at the age of 3 years, though they can be maintained till the age of 5 to 6 years (Chatterjee *et al.* 1995). It has been reported that with the increasing age of plants the amount of alkaloid

emetine or cephaeline reduces. During harvesting the plant is dug out, the root portions are separated by cutting at 6–7 cm above the root – stem transition region, since alkaloids are also present in the lower region of stem. They are then dried in shade till the moisture content reaches to 10–12% and then are stored in dry cool place, usually packed in gunny bags.

Yield

Yield of dried roots is about 88 q/ha. These dried roots are sold at about ₹ 610 per kg depending on their alkaloid (emetine) contents and the leaves cost around ₹ 125 per kg.

Processing

After harvest and wash, the roots are spread out and are dried as rapidly as possible under sun, but are protected from heavy dew during nights. After 2 – 3 days of drying, the roots are cut into pieces of few inches length. These pieces are then shaken in a sieve to separate any remaining adherent earth. Finally they are packed in polythene bags for marketing and export.

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Safed Musli

(*Chlorophytum borivilianum Santapau & R.R. Fern.*)

Safed musli (Family Liliaceae) is also called Khairua. Demand of this medicinal plant is increasing much more than its supply. As per the estimate the world over supply of safed musli is only 5000 tonnes whereas its demand has increased to 35,000 tonnes. This demand can be only fulfilled by its more and proper cultivation. Cultivation of safed musli in India is in Madhya Pradesh, Maharashtra, southern Rajasthan, north Gujarat, Uttar Pradesh, Bihar, Odisha, Haryana, Delhi and Andhra Pradesh. It can be also tried in Karnataka and Tamil Nadu. This important medicinal plant is found in the forests but because of indiscriminate removal, this plant is now endangered. This situation has necessitated people to cultivate it. Outside India it is found distributed in Burma.

Description of plant

Safed Musli is a small perennial herb full of leaves appearing over ground with the advent of summer rains (Santapu and Fernandes1955)). It has a fleshy root. The roots are fascicled, cylindrical, 1-8 in number; brown to black but when skin is taken out it becomes white in colour. On maturity, the root tubers are 5-10 cm long. Leaves are radical, 6-13 in number, spirally imbricate at the base, sessile, linear ovate, acute apex and lightly narrowed at the base. The leaves have parallel venation. It spreads horizontally. Its lower surface is rough and margins are wavy. Scape is solitary, unbranched and 15-30 cm long. Three-fourth of the scape bears flowers. The flowers are white bracteate, pedicellate, usually arranged in alternate clusters each consisting of 3 flowers. The flowers at the edge are closely packed. The bracts are linear, papery and purplish 1-1.5 cm long. Pedicel looks whitish, pointed and 6-10 mm long. Perianth are 6, linear acute and 3 – 4 nerved. Stamens are six, and as long as perianth. Its filaments are glabrous. The anthers are yellow linear, and dehisces by longitudinal crack. Its style is slightly longer than stamens and swollen at the apex. Ovary is trilocular. Fruits are capsule, green to yellow and almost equal in length and width. Seeds are onion like, black in appearance with angular edges.

Varieties

Two types are found, i.e. Black type and White type. White type is more popular. Bordia *et al.* (1995) reported the varieties RC-2, RC- 3, RC- 4, RC-16, RC-20, RC-23, RC-24, RC- 33, RC-37 in white type. These strains showed

high content of saponins.

The variety Jawahar Safed musli 405 was released in 2004 under AICRP on Medicinal and Aromatic Plants, JNKVV, Mandsaur.

Chemical constitution

Safed Musli contains albumin. The glycoside 1.9 –3.5% is reported in Safed Musli by Trivedi (1991). Gupta *et al.* (1979) reported the presence of galactoglucan in the fruits of *C. arundinaceum*. Bordia *et al.* (1990) and Seth et al (1991) reported that the major constituents of Safed Musli are carbohydrate (42%), proteins (8–9%), root fibres (3 – 4%) and saponins (2–17%). Saponin is considered to be medically important constituents of the root. The amount of saponins is around 0.17 mg/10 g of dry seeds, though it may vary in different genotypes. The higher content of saponins was observed in RC –2, RC – 16 (17.0%), RC – 36 (16.6%), RC – 24 and RC – 33 (10%). The mucilaginous extracts of Safed Musli are used as an emulsifying agent in relatively lower concentration.

Medicinal uses

Roots are used for:

- Safed Musli is useful in diabetes and post gynaeconological problems.
- It is also used to enhance lactation in ladies.
- It has property of rejuvenation of physical weakness. It is also an important muscular tonic. The dry roots of Safed Musli are an excellent tonic and aphrodisiac drug given to cure general disability (Sivaraman and Balchandran, 1994).
- It improves complexion and is useful in general cough, asthma, piles, skin diseases, impotence, jaundice, urinary diseases, leucorrhoea and menorrhagia.
- It is used to prepare the tonic *chayavanprash*.
- It is supposed to be equal to Panax ginsing and Shilajit. Therefore safed musli is a high value crop in India.

Cultivation technology

Tuberous roots of safed musli grow in the soil. Therefore the soil should be soft and porous. Loam soil having sufficient organic matter and good drainage is the proper soil for its good cultivation. But if the soil is too porous then the roots become thin which is an undesirable feature.

Water: For good yield of safed musli sufficient water is required. The crop is planted in June with the advent of rains, which may continue till September-October. So during these months irrigation may not be required. However care should be taken that till safed musli is not dug out the soil should remain moist. After rainy season the field should be irrigated at interval of 10 days

for proper growth and development of roots. After the leaves dry out till the crop remains in field, light irrigation should be continued at 10 days interval. Water stagnation must be avoided. For irrigation any source will be good. Sprinkler or drip system or any other system may be followed.

Nutrition: Five types of nutritions – farm yard manure, fertilizer, green manure, bone meal and soil conditioners are required for safed musli as mentioned below:

- Farm Yard Manure: It is very important nutritional requirement. Five to seven trolleys of this manure per acre should be given. It should be applied before sowing and mixed uniformly with the soil.
- Fertilizer: Though addition of fertilizer increases yield, it should be avoided as far as possible particularly for those crops grown for export market.
- Green Manure: After safed musli is harvested in January-February, the field remains vacant until May-June. During this time a short duration crop such as sun hemp or dhatura or any vegetable should be taken up. After harvesting it, the green should be ploughed and mixed in the soil.
- Bone Meal: Application of bone meal has been found to be very beneficial. Amount of bone meal to be applied depends on the financial capacity of the farmer. But at least one to two tonnes of bone meal per acre should be applied.
- Soil Conditioner: Experiments have revealed that with application of soil conditioner the soil gives more yield of safed musli. "Mycimil" produced by M/S Hindustan Antibiotics has been found to be quite effective.

The field should be ploughed by mould board plough. If there is any green manure crop, it should also be ploughed well. Afterwards 5 to 10 trolleys of farm yard manure should be uniformly mixed well with the soil. Deep ploughing should be done once more followed by cultivator, harrowing and levelling.

Preparation of bed is essential for good crop. A raised bed of 91.44 to 106.68 cms. wide and 9" to 12" should be prepared. Along with this, channels should also be made. For movement, some space should be left lining the beds.

Planting

Planting material of safed musli is the fingers (tuberous roots). The fingers can be collected from the harvested crop. One thing is important that the fingers must have disc or some part of crown, otherwise there may be some problem in germination. Second important thing is that the fingers outer covering should not be damaged. In fact after harvesting the well developed fingers should be

separated and should be scrapped and dried for marketing. Other fingers, which are small, should be used for sowing. Seed tubers should weigh between 2 g to 5 g. Planting material of high quality should be obtained from reliable firm.

Care should be taken that if the sprout is smaller than 1 cm, they should be collected by cutting a small stem disc along with an individual fleshy root (Anonymous, 1989-90), (Boardia and Jat, 1991) and (Anonymous, 1990-91). According to Boardia and Jat, 1991, on the top of ridges of 6" to 8" height and a row distance of 12" is adequate for obtaining commercial yield. Approximately, 250-300 kg of fleshy roots are required for planting 1 hectare land. Propagation by root result in a plant population true to the mother plant. Propagation can also be done successfully by tissue culture.

Flowering

Plants of safed musli at about 2 months age produce flowers which later on produce small black coloured seeds, germination varies from 11 to 24% (Jat and Bordia, 1990) after 12 to 16 days of sowing. Dalal *et al.* (1987) reported 13% germination in 1 year old seeds. Hence use of seed is not advised for commercial purpose.

As mentioned earlier fingers weighing 2 g to 5 g are used as planting material. These fingers are planted at a spacing of 6" × 6". Hence in 1 acre 80,000 tubers having crown are required. Total weight of these fingers may be 3 to 4 quintals per acre.

To enable the crop free from diseases it is advised that before sowing fingers must be dipped for 2 minutes in 2% solution of the fungicide bavistin. Seed treatment can also be done organically by dipping in cow's urine.

After preparation of the field, beds measuring 3 to 3.5 ft. wide and 9" to 12" wide are prepared by beginning of the rainy season and 2" holes are made at a spacing of 6" × 6" in the bed. To make the holes special equipment can be developed. One thing is essential that the field should have sufficient moisture at this time. In every hole 1 finger is sown. In case the fingers are very small then 2 can be sown per hole. If the tubers are 5 g in weight then the spacing can be increased. The fingers should be sown about 1" deep. Care should be taken to see that while sowing the crown should be up and lowest end of fingers should be down. After sowing, the holes should be closed by hand. In the sowing process one person makes holes in the bed and other person does sowing of the fingers. If irrigation facilities are available then safed musli can be sown in mid May.

Roots of safed musli should be prominent so that after scraping the outer covering sufficient saleable material will be obtained. If the fingers become thin then less amount of saleable material will be obtained. To avoid thin fingers we should avoid to prepare the field extra porous because then the roots penetrates still down and so become thin. On harvesting if some thin

fingers are obtained then it should be better to use them as planting material.

After a few days of sowing the fingers sprout and the plant grows. By August the plant flowers which later on forms seeds. By October-November leaves automatically dry out and tubers remain in the ground.

Plant protection

No major disease has been recorded in safed musli. Hence there is no need to spray plant protection chemicals. Because the roots remain in the soil therefore, natural calamities such as hail storms don't affect the roots. Water must not stagnate in the field otherwise safed musli is almost free from plant protection problems.

During storage the fleshy roots get infected by *Aspergillus* sp. and *Fusarium* sp. The treatment of fleshy roots with thiram and captan at 4 g/kg reduced rottening of fleshy roots during storage and also it enhanced its sprouting percentage (Anon, 1991 – 92).

Harvesting

After 90 to 95 days of planting when the leaves dry up some people think that the crop is ready to harvest. It is absolutely wrong. In fact after one to two months after this stage the crop should be left in the field. The soil should be kept moist with light irrigation. Initially, colour of the fingers is white. Gradually the colour changes to blackish brown. This colour is the stage of maturity and an index for harvesting. During January the finger should be dug out. The fingers having crown should be used for planting material. The fingers may also be cut singly, scraped and dried for sale.

Sometimes due to non availability of labour or due to any other reason the farmer may be unable to dug out the fingers. In that case nothing much to worry. In rainy season these fingers will automatically sprout and grow in to new crop. On maturity the crop will be only 50 to 100 percent more than the original crop. Whereas the yield would have been 4 to 5 times more when the fingers would have been planted in normal way. But if the farmer is unable to dig out the fingers then every year there will be some increase in the yield. But after 7 years there will be no further increase in yield.

Processing

The dug out fingers have some soil. This has to be washed out before scraping the outer cover. For washing purpose the fingers should be kept in basket. This should be placed under falling water. After washing the outer covering of the fingers must be scraped out.

After leaving the fingers for use as seed material all other fingers should be scrapped to remove the outer covering. Scrapping is a simple activity. Unskilled labourers and children can also do this work. It is labor intensive work. So it

takes long time. There are two methods of scrapping:

(a) Rubbing the fingers on stone: Safed musli dug out from field is generally scrapped by rubbing on stone. But it results in three problems:

(i) Occasionally more pulp gets removed leading to economic loss.

(ii) Occasionally some skin remains which lowers the quality of the produce.

(iii) The produce scrapped by rubbing on stone has less acceptability in market.

(b) Scrapping by knife: but success has not been obtained so for.

This method is easier and also better for scrapping fingers of safed musli. This results in product of high quality. The method is very simple. Even children can attend this work satisfactorily. Each labour can scrap out 2 to 3 kg of tubers per day.

In order to avoid this labour intensive work of scrapping, experiments are underway to remove the outer covering of the tubers by chemical treatment. After scrapping, safed musli is dried out in sunlight for 2 to 3 days so that fingers are dried completely.

Scrapping and drying out experiments has shown that only 20 to 25% of dug out weight is obtained finally after scrapping and drying it.

Yield and Price

Yield of safed musli depends on several factors. One of the important factors is finger size. From fingers weighing upto 5 g on harvest weight of the product is 4 to 5 times more. From fingers weighing more than 5 g generally 3 times more produce is formed. Weight of fingers have been seen to range from 2 g to 270 g but normally weight of finger is 20 to 25 g. Similarly the number of fingers per bunch has been found to vary from 2 to 65 but normally per bunch 10 to 12 fingers are seen. In this way it can be assumed that yield of safed musli will be 5 to 10 times more than the amount of planting material (fingers) used. In other words the yield may vary from 20 to 40 quintals per acre. A yield of 1 tonne of fleshy roots per acre has been reported (Anonymous, 1989-90). After processing and drying it reduces to 200 kg of dry safed musli per acre. The sale price of dry safed musli is around Rs 1000 to 1200 per kg.

Packing

Before marketing, safed musli is packed in polythene bags. In polythene bags, it remains for a long time and does not get damaged by outside moisture. Good quality safed musli should be fully white on drying and should not have any coloured spot.

Conservation of seed

To conserve the fingers for seed in January, after digging out the produce

all big size fingers should be broken, washed scrapped and dried for sale. The remaining small sized fingers having crown should be used for seed. Sowing time is mid June. So seed has to be stored for about five and a half months. Cold storage can not be recommended because it will reduce the sprouting viability of the seeds. In fact, for the storage of safed musli planting material, there should be special chambers having 70 to 80% humidity. But it will be a costly affair for individual farmer. Therefore, a low cost technique of preservation is that a pit should be dug in a shaded place. The seeds (fingers) of safed musli are placed in that pit and covered with soil. In June, the soil covering should be removed. The tubers are taken out and sown in the field. Safed musli can also be successfully cultivated as an intercrop. Some companies are cultivating safed musli as intercrop in teak plantation. In a crop, which takes a long time to give returns, safed musli can be cultivated as an intercrop. Thus, good income can be generated without much investment. In papaya plantations, intercrop of safed musli can be taken up very profitably.

Training

Training for cultivation of safed musli is available with:

1. Director, Mittal Musli Farm, Jalgaon Jamod, District Buldhana, Maharashtra 443402.
2. Director, Shanti Herbal Agro Farm,206, Silver Arcade 56, 1 NewPalasia, Indore - 452001

Availability of planting material from these places is possible.

Economic viability

As mentioned earlier there are 80,000 plants per acre. Out of this 70,000 plants survive. From each plant about 30 gm of safed musli is obtained. Therefore, from 70,000 plants 2100 kg safed musli is obtained. After scrapping and drying this will reduce to 400 kg only (20 to 25% of the fresh weight). Beside this, planting material for one acre will be obtained. According to experts, per acre yield of dry safed musli varies from 3 to 5 quintals.

According to prevailing market rate of ₹ 1,000 to 1200 per kg of dry safed musli, four quintals of dry safed musli will value rupees four lakhs. Beside this, planting material valued at ₹ 50,000 to ₹ 1,00,000 also will be obtained. Studies on expenses and sale of safed musli have indicated that a net profit of as high as ₹ 2,50,000 can be obtained. There is no problem in marketing. The agro-climate of large part of India is suitable. Further research is needed on improvement in seed germination, development of higher yielding varieties which have resistance to disease and pests.

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Ergot

[*Claviceps purpurea* (Fr.) Tulasne]

Ergot (Claviciptaceae) is also called Ergot of Rye, Spurred Rye and Horned Rye. It is largely produced in Spain, chiefly Galicia and in southern and central Russia. To some extent it is found distributed in Germany, France, India and other countries (Atal and Kapur, 1982). In India it is found distributed in the states of Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Gujarat, Uttar Pradesh, Madhya Pradesh, Rajasthan, Punjab, Haryana, Himachal Pradesh and Jammu and Kashmir.

Plant description

Ergot are hard curved brownish or black bodies measuring about 15 –20 cm in length and 0.2 – 2 cm in width. The sclerotia is more pointed towards open end than at the bottom end (Bentely and Trimen, 1992). These hard

Ergot

curved, black bodies are in fact the resting stage of the ergot fungus and are given popular name as 'sclerotium'. If these bodies get mixed with food grains, may infect man and animals and the infection is called 'ergotism'.

Varieties

The ergot fungi are grouped broadly into two types of categories, ie. (a) clavine type (b) eryoline or lysergic acid type. According to Atal and Kapur (1977) strains of ergot fungus are R–38, R–40, R–55, R–56, R–56a, R–56 b, R–56 c, R–56e, R–57, R–58. Out of these R–38, R–58 and R–40 are ergotoxin strains and R – 57 are ergometrine strain while all others are ergotamine strains.

Chemical constituents

The ergot sclerotia contains over one hundred chemical compounds falling in 10 different groups. The ergot alkaloids are grouped under three categories:

- The ergotamine group containing ergotamine, ergosine and corresponding isomers.
- The ergotoxine group consisting of ergocornine, ergocristine and ergocryptine and their isomers.
- The ergometrine group consist of isomers and a pair of water-soluble bases. They are simple hydroxypropyl amides of lysergic and isolysergic acids.

Chemical constituents

The types of alkaloids produced by ergot are ergoscaline, ergoscalinine, ergotamine ergotaminine, ergosine, ergosinine, ergocristine, ergocristinine, ergocornine, ergocorninine, ergokryptine and ergokryptinine. Some other alkaloids are festuclavine, pyroclavine, castoclavine, lysergene, lysergol, agroclavine, triseclavine, setoclavine, isotriseclavine, isosecoclavine, elymoclavine, peuniclavine, sopenniclavine, molliclavine, secaclavine and chanoclavine.

Parts used: Sclerotium (compact mycelium or spawn).

- At present the plant is used in hastening the childbirth, stoppage of bleeding and also for expulsion of placenta.
- In obstetrics the ergot alkaloid can be administered intravenously after the appearance of the anterior or posterior foetal shoulder, which results in almost immediate childbirth besides expulsion of placenta in less than 20 min in almost all the cases. Therefore, the post partum hemorrhage is now no more a problem
- In migraine dihydroergotamine in combination with caffeine and methylsegide have been found to be very effective drugs by blocking servtonin, ultimately resulting in relief due to migrane headache. The

methylsevgide acts as a prophylytic drug as well as it helps in the control of migraine.

- Some new derivatives such as 2- bromo- derivatives of ergokrypine, d-6-methyl-8-cyaomethylergoline, d-6-methylergolinyl-1-acetamide, n-(d-6-methyl –8-isoergolenyl)-n, 'n'- diethlurea, 9-10- dyhydro derivatives, d-2- chloro- 6- methyl-8-b- cyanomethyl- ergoline have been reported as active prolactin inhibitors. For treating human prostrate and breast cancer in their initial stages 2-bromoergokrytine, d-2-chloro-6-methyl-8-cyanomethylergoline, d-6-methylergotinyl –1-acetamide and n-(d-6- methyl –8- isoergonyl)-n-ndiethylurea are used in the drug.
- For parkinsonism bromokryptine and lergotrile are used as reported by Liberman *et al.* (1975) and Shaw *et al.* (1976). It is also found to be effective in treating galactorrhea, amenorrhea, acromegaly and some other hormone dependent disorders.
- In general the alkaloids lead to the rise in blood pressure, contraction of blood vessels and also contraction of uterus. But it was found by some workers that derivatives of hydrogenated alkaloid had just reverse action to the above effect

Development of ergot sclerotia on rye plant

The favorable conditions for the growth of ergot are slow temperature (average is 15–16°C) and moisture (humidity in the atmosphere is above 60%). The yield of ergot is lower if the atmosphere is dry with higher temperature (ie. more than 22°C) or if heavy rainfall and hailstorms occurs. The infection of ergot on rye plant takes place under two steps - first infection is called primary infection which is found as a 'honey dew' formed at infection sites on the inoculated rye spike within 12–18 days following inoculation, when the temperature is 15–18°C. In low temperatures, the growth is delayed. The secondary infection takes place with the help of honeybee and other pollinating insects, which carries the infection from 'honey dew' to the other spikes in many different fields.

Plant protection

Since ergot is grown on rye, the plant protection of rye plant should be undertaken so as to keep the growth of plant as well as that of ergot healthy. It was recommended to use 0.226 kg. 2,4- D/ac. for the control of mostly annual and broad-leaved weeds. Even a suggestion has been made to spray some herbicides for post-emergence weed control in this crop, out of which MCPA – Sal, 2,4- D- Amine and 2,4-D-Esters at 24 Oz. 20 Oz. and 10 Oz/ac. respectively can be easily used in crop of rye.

Harvesting

The collection of ergot is done after 8–10 weeks after the last inoculation

or two weeks prior to the ripening of the rye grains. The mature sclerotia become liable to get dislodged from the spikes with slight wind or rain and so need early harvest (Sastry, 1995). Therefore, these well developed sclerotia needs to be harvested 15–20 days earlier than the rest of the harvest.

Harvesting is done by hand picking by individuals and also spikes can be cut to collect the ergot. After harvesting the spikes are dried for 1–2 days. They are then dislodged. The small ergot is picked either manually or by any mechanized equipments.

Yield

About 4 to 10 kg of ergot is collected from every 100 kg of rye grains. The average yield of 150 kg per hectare under large scale cultivation is seen in India under optimum weather conditions. Though the yield highly fluctuates with weather condition both at time of inoculation and also during development of ergot.

Processing

Processing includes drying, packing and storage of ergot. During high temperature there is possibility of transformation of l- form (active) of the ergot alkaloid to d- form (inactive). So the drying is carried out under shade. Initially the harvested material is spread thinly on a clean cemented floor or a canvas and are stirred 3–4 times so as to avoid any petrification of the moist ergot. For packing care should be taken that the moisture content of ergot does not exceed 6%, since more moisture can make it susceptible to infection. The packing should be done in polythene bags so as to prevent it from any moisture reabsorption. While packing, before storage, 15 g of powdered camphor is added to every 10 kg of package or a cotton dipped in chloroform is kept inside. It prevents the ergot from pests.

Further studies on claviceps can open some other path in the field of fermentation, fermentor designing, enzyme technology, genetic engineering, applied mycology and industrial microbiology. Large scale production of ergot would help in producing drugs and pharmaceuticals at a cheaper and more efficient manner.

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Guggul

[*Commiphora wightii* (Arnott) Bhandari]

Guggul (Burseraceae.) is also called Indian Bdellium. It originated in Africa and Asia and the genus is widely distributed in tropical regions of Africa, Madagascar, Asia, Australia, Pacific Islands, India, Bangladesh and Pakistan. Atal *et al.* (1975) reported the distribution of *Commiphora wightii* in India over Rajasthan, Gujarat, and Maharashtra and Karnataka states. Of these the main Indian commercial source of gum guggal is Rajasthan and Gujarat. Outside India, it was reported to be in Sind and Baluchistan provinces (Farooqui and Sreeramu, 2001). The occurrence of guggal was less in the areas where heavy rainfall is received.

Guggal is a shrub of 3–4 m height. The branches of plants are crooked, knotty and have sharp spines. From the older parts of the stem the papery barks peel off. Leaves are sessile, alternate or fascicled and 1–3 foliate. Leaflets

Guggul

are glabrous, sessile or subsessile, obvate, serrate (sometimes serrate only towards the apex), 1–5 cm long and 0.5 to 2.5 cm broad.

The plant is dimorphic, one having bisexual and male flowers, and the other having female flowers with stamminodes (Abedin and Ali, 1972; Kumar and Shankar, 1982), a third category is also there in which plants have only male flowers (Rao *et al.* 1984).

Variety named Marusudha evaluated in Anand, Gujarat has higher yield.

Chemical constituents

The oleo-gum-resins are mixture of resin, gum, volatile oil and sometimes with some other substance. The oleo-gum-resin has ketonic and non-ketonic fractions. The ketonic mixture has around 12% of ethyl acetate soluble neutral part. It constitutes of 8 compounds, which belong to class "steroid" and two of them, ie. z and e - guggalsterone, contains around 2% of the gum resin, which is responsible for the lipid lowering activity of guggal.

The non-ketonic compounds exert a synergistic action on the biological activity of the ketonic fraction. During standardization, it was found that ethyl acetate which is also named as "guggulipid" when extracted from guggal contained 4.0 g of z and e-guggalsterones per 100 g. Estimation of these steroids is readily done by high pressure liquid chromatograpy.

Parts used: Tree bark, gum root, leaves and bark's resin are used.

- The oleo-gum-resin of guggal is an indigenous drug and is effective in the treatment of obesity, arthritis and several other diseases mentioned in ayurveda.
- The resin is largely used as incense and as a fixative in perfumery and in medicines.
- In medicines it is used as an astringent, antiseptic, stomachic, carminative and digestant.
- The oleoresin causes an increase of leucocytes in the blood and stimulates phagocytosis.
- It also has the property of being diaphoretic, expectorant and diuretic and is said to be a uterine stimulant and an emmenagogue as well.
- It is highly effective in obesity, arthritis, indolent ulcers, weak and spongy gums, pyrrhoea, alveolaris, chronic tonsillitis and pharangyitis, ulcerated throat and chronic dyspepsia.
- Inhalation of the fumes of burnt guggal is recommended in hay fever, acute and chronic catarrh, chronic laryngitis, chronic bronchitis and phthisis.
- It is a constituent in ointments for ulcer.

Cultivation technology

It can be propagated vegetatively by stem cutting or by seed. The soil needed for the plant should be sandy to silty-loam, poor in organic matter but rich in several other minerals, with some moisture retaining capacity. The climate for plant should be warm and dry (Atal and Kapur, 1982). Two to three ploughing should be done. Plant to plant spacing of 3 to 4 m in rows is recommended. The pits (30 × 30 × 30 cm) are filled with a mixture of FYM and soil. The mixture is mixed with aldrin (5%) to prevent the plant from termites.

- **Propagation by seeds:** The seed have a hard seed coat due to which the germination is slow as well as poor (5%), so it is not commonly used for plantation, or achieving good germination the seeds are mechanically scarified with sand paper and are kept under running water for 24 hours.
- **Propagation by stem cutting:** Semi hardwood cuttings of 15–20 cm length with width of 10 mm can be taken and be treated with IBA or NAA, growth regulator solution, these cuttings are then planted in manured and well prepared nursery beds in the month of June to July. These cuttings are regularly irrigated. The cuttings sprout in 10–15 days and are ready to be planted in the field after 10–12 months, during the next rainy season. The percentage of rooting in stem-cuttings is around 80–94%. Air layering is also found to be successful.

Plant protection

Before planting the pits are treated with BHC (10%) or aldrin (5.0%) to protect the new plant from white ants damage.

Gum tapping and pruning

At the age of 8–10 years the plant is ready for tapping. Tapping is the procedure of making a careful incision on the bark to yield resin from the incision. Usually the incision is made after November but before April. The collection of resin is done after an interval of every 10-15 days.

On pruning the guggal plants in May, in arid regions of Gujarat and Rajasthan, the maximum of guggalsteron (0.06%) was found. Pruning is considered to be important.

Yield

At the age of 8-10 years every plant yields 700-900 g of gum resins.

Processing

From the time of making an incision a small quantity of guggal gum is mixed with water and is applied on the incised place with the help of prick-

chisel. So the resin obtained needs to be separated from gum. The separation is brought about by either hot expression or solvent extraction at 120–130°C (Dalal and Patel, 1995). The solvent extraction method is more beneficial than the hot expression as it yields 61% of resin while the yield of hot expression is 10% less than that of the solvent extraction. The resin obtained is transparent in thin films, but becomes opaque in bulk.

Genetics of sex-determination in the species will help to raise the seed productivity.

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Datura

(*Datura stramonium* Linn. Syn. *Datura tatula* Linn.)

Datura of Solanaceae is also called Thorn Apple. It originated in south America. It is found distributed in arid and semi- arid regions of Punjab, Haryana, Rajasthan, Gujarat, the central plateau of Andhra Pradesh, Maharashtra, the southern peninsula of Tamil Nadu, Karnataka etc. (Farooqui and Sreeramu, 2001). World distribution of the plant is in Africa, Asia, Europe, Mexico, India and south America.

Datura is annual, perennial herb or shrub growing mostly in warmer parts. Datura has a height of 90–120 cm. Leaves are ovate almost entire or dentate and softly tomentose on both the sides. Flowers are white, solitary, funnel like 14–16 cm long and toothed, corolla 10 in number, stamen 5–6, more or less reaching the mouth of corolla tube (Farooqui and Sreeramu, 2001). Fruit is a capsule reflexed, covered with long spines breaking irregularly.

Datura

It contains 0.3–0.5% of tropane alkaloids, chiefly hyoscyamine and small quantities of atropine and scopolamine (hyoscine). The alkaloid content in different parts of datura is as follows: leaves having 0.41–0.45% of alkaloids, stem having 0.25–0.26% of alkaloids, fruits having 0.46% of alkaloids, seeds having 0.19% of alkaloids and roots having 0.21% of alkaloids.

Parts used are leaves, seeds, flowering tops and roots for following:

(i) Plants have hyoscyamine, which is active in paralyzing effect on nerve ending and less active in its stimulant action on the central nervous system.
(ii) Hyoscyamine and its salts are used for therapeutic purposes.
(iii) Hyoscyamine hydrobromide treats delirium, tumour and menia.
(iv) Parkinsonism can also be treated with the alkaloids of the datura.
(v) Hyoscine alkaloid is mainly used as a preanesthetic in surgery, in childbirth, in ophthalmology and prevention of motion sickness.
(vi) It is also extensively employed in relief of withdrawal symptoms in morphine and alcoholic addiction, in paralyzing agitans, postencephaletic parkinsonianism and to allay sexual excitement.
(vii) It finds extensive use in obstetrics and surgery as pre-anesthetic in conjunction with morphine and other analgesics.
(viii) The leaves are smoked to relieve asthma.

Datura can be grown on variety of soils but prefers rich clay loam soil with sunny climate (Kaul and Singh, 1995). The land needs to be ploughed twice or thrice followed by planking. Farm yard manure (5 trucks/h) should be added to the field. Datura is sown in March–April in temperate areas and during November in north Indian plains. The seedlings are transplanted to the field in May–June in temperate region and November–December in subtropical regions. The plant is propagated by seeds. The method is described below.

Cultivation by seed sowing

In case of direct seed sowing the germination is low because of the presence of an inhibitor (Zutshi and Atal, 1970). Soaking the seed in water for a night and washing it 2 – 3 times by freshwater before they are sown can enhance the germination of seed. Also the seed germination can be hastened by alternative exposure to freezing and thawing. This method makes the seed coat weaker. In case of direct sowing, the seeds are suggested to be sown 1 m apart in rows. Seeds are sown at the rate of 7 – 8 kg/ha. In 15 days the seeds germinate and regular thinning and weeding is done, keeping plant-to-plant and row to row distance of 75 – 100 cm.

Nursery raising

The nursery beds are prepared by mixing well rotted FYM into the beds. The seeds are grown by broadcast method. The beds are kept moist. About 2

kg of seeds are required to raise seedling for planting one hectare. The transplantation is done when the seedlings are about 15 cm in height and have 4 leaves. The plant needs regular irrigation. A spacing of 80 – 85 cm row to row and plant to plant is recommended for high yield. Interculture, weeding, organic manuring, irrigation and plant protection are done normally.

Plant protection

- Thrips act as vector in transmitting mosaic virus, which can be controlled by spraying insecticide like metasystox (1.5 ml/lit).
- Wilting is caused by *Scleoritium rolfsii*. No control measure is reported but field sanitation and crop rotation can be a remedy.
- Root and Foot Rot are caused by *Corticium solani*. The young seedling can be saved by drenching them with a solution of copper fungicide (0.3%) in the nursery.
- Viral disease like distortion mosaic, venation mosaic, rugose leaf curve and little leaf have been found which can be checked by spraying suitable insecticides.

Harvesting of Datura is done after 6–7 months of sowing. While harvesting, entire plant is cut. At this stage the fruits are matured but green. These are dried in sun and in shade. The leaves are stripped and dried separately. The seeds are shaken off from the capsules when fruit begins to burst.

Yield of leaves is 11–17 q/ha and the seeds may yield upto 8 q/ha. Development of high yielding varieties resistant to diseases and pests is needed.

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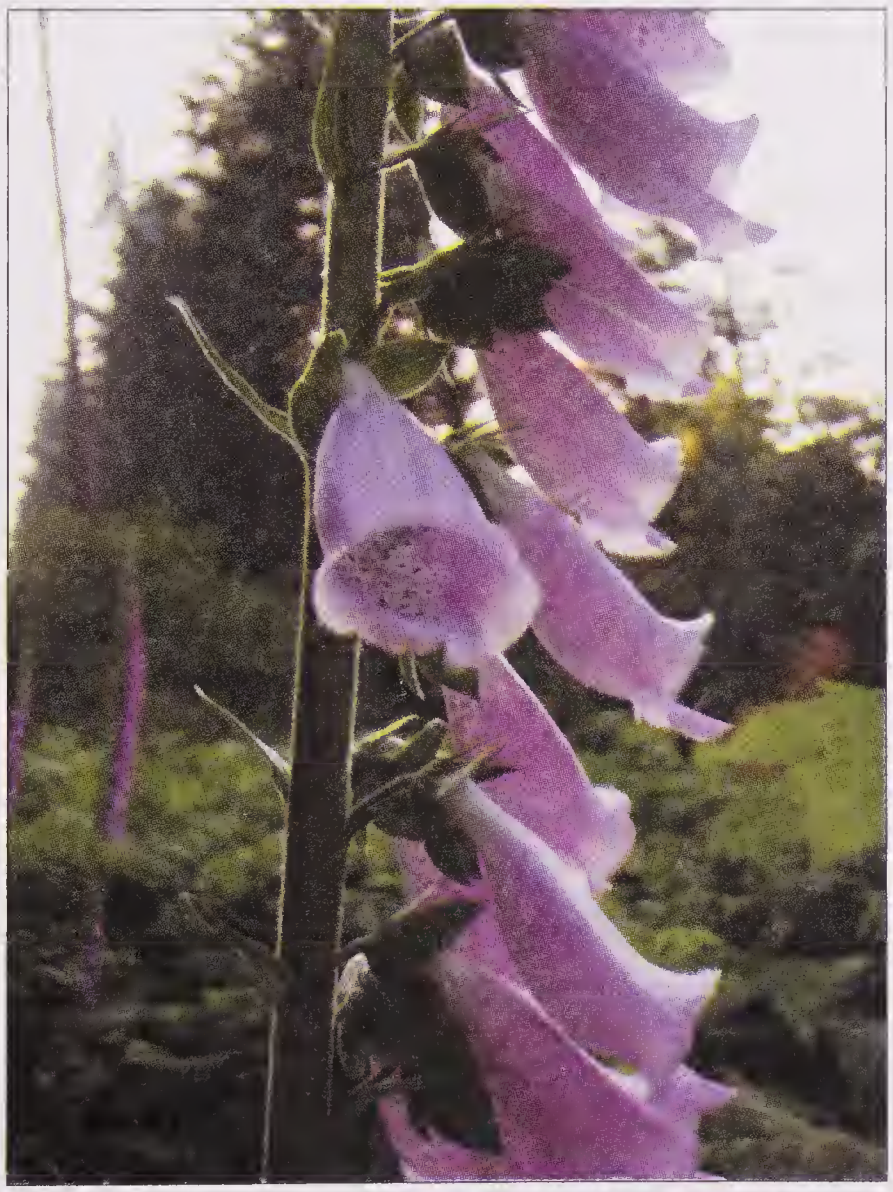
Foxglove

(*Digitalis purpurea* Linn.)

Foxglove (Scrophulariaceae.) is also called Tilpushpi. Its origin was west central Europe (Atal and Kapur, 1982) and distributed in Kashmir valley in hills of north western Himalayas and nearby forests in Chamba Hills (Madhya Pradesh) and also in south India it is being successfully cultivated in Nilgiri Hills (Tamil Nadu) and adjoining hills of Kerala state. It is found distributed in the British Islands, Canada, western Europe, France, Germany, Hungary, Mexico, UK, USA and some Asian countries.

Plant description

Foxglove is a biennial herb. Plant is erect, branched, herbaceous and attains the height of 60-90 cm. Leaves are simple, alternate, opposite or whorled



Foxglove

exstipulate. Flowers are zygomorphic, pentamerous, hypogynous and bisexual. It has 4–5 partite bracts. Sepals are gamosepalous, lobed in imbricate aestivation. Petals are 4 in number, gamopetalous, bilipped, sometimes spurred and in imbricate aestivation. Stamens are two to four in numbers. Anthers are bithecate, hairy, dehiscing by longitudinal slits and epipetalous (Farooqui and Sreedhar, 2001). Ovary bicarpellary, syncarpous, superior with many ovules and single or bilobed style, stigma is bilobed. Fruit is a capsule.

Genetics and breeding

Sharma (1983) studied the characters of EC-115996 culture of *Digitalis lanata* grown under Solan conditions. According to him the selection in the germplasm provides a possibility to register genetic improvement for yield in this crop. Maximum heritability is recorded for days taken into initiation of flowering (65%). High heritability estimates in broad sense for other economic characters like glycoside contents, leaf yield, number of leaves, number of flowers and number of fruits per plant have been found to accompany high genetic gains which were 59.3, 51.5, 37.9, 28.5, 25.5% respectively, suggesting that these can form effective selection criteria in crop improvements. (Sharma *et al.* 1990). Research should be done to develop varieties, which can yield still higher amount of digitoxin, talin and gitoxin and should have resistance to diseases and pests.

Varieties

From several researches by National Bureau of Plant Genetic Resources, Delhi EC-115996 (ex. Poland) was found to be superior in foliage as well as glycoside content. This was then used to make selection and the result was the development of D-76, D 21, DYF and DPF, which are high yielding selections. The leaf yield of these selections varies from 32 to 37 q/ha and the total glycoside content is 0.93 to 0.99%. The colour of flower and the flowering pattern varies slightly in these selections.

Chemical constituents

The leaves of *Digitalis purpurea* contains three glycosides, ie digitoxin, gitalin and gitoxin. The leaves of *Digitalis lanata* also found to be 3–4 time active than those of *Digitalis purpurea* (Voroshilov, 1941). Leaves are found to have digitoxin and gitoxin. Other glycosides are digitoxigenin, glucodigitoxigenin – bis – digitotoxoside, glucogitaloxigenic, bisdigitoxoside, glucovatromonoside, glucogitoroside, glucolanadoxin, varadoxin, stropeside and anthraquinone.

Parts used: Leaves and inflorescence for:

- *Digitalis purpurea* and *Digitalis lanata* are known for yielding cardiotonic glycosides (Anon 1973).

- In case of burns it is more selective in preserving the cells severely injured by heat.

Cultivation technology

It grows well in lower altitudes. The crop requires fairly warm conditions during vegetative growth to produce maximum leaf and glycoside content. It prefers well-drained silty loam to clayey loam soil, rich in organic matter with adequate amount of moisture. Germination of seed takes place after 15–20 days of sowing. In 60 days the plant attains the height of 10 to 15 cm, which is the stage for transplanting. Fresh seeds should be sown immediately as the older seeds loose viability. The land should be leveled and deep ploughing and pulverization should be done. Then 8 kg of seeds/ha (Singh, 1982) should be sown, at the depth of 1 to 2 cm in a line. Sowing should be done in spring season. Seeds should be pre-sprouted by soaking in water and incubated at 30°C for two to three days. In nursery, the rate of germination of seeds is found to be higher than that of direct sowing. Nursery beds are prepared in strips of 10 × 1 m. Each bed is treated with 5 baskets of FYM, compost or leaf mould. Irrigation, interculture, weeding, organic manuring and plant protection are carried out normally.

Plant protection

- The pests like cutworms, hairy caterpillar, and aphids can be checked by dusting sevin wp or 0.5% malathion which is given as foliar spray.
- Leaf blight caused by *Alternaira* sp. is prevented by spraying with any copper fungicide at the rate of 0.1–0.2%.
- Anthracnose, caused by *Collectotrichum fuscum* Laubert. For control the seeds are treated with hot water at 55°C. The crop should be regularly sprayed with 0.5% Bordeaux mixture (lime + copper sulphate)
- Leaf spot, caused by *Septoria digitalis* Pass and *Phyllosticta digitalis* Bell. Control measures (a) the spreading up of disease can be checked by spraying Bordeaux mixture (1: 1.5%), capton (0.2%) and zeneb (0.2%). (b) the use of protectants helps in controlling the disease at early stages.
- Virus diseases of *Digitalis: Digitalis* have been found infected by various kinds of viruses like Tobacco Mosaic Virus, Cucumber Mosaic, Tobacco Ring Spot Virus, etc. Control: Spray of extracts of some insecticidal plants can inhibit the virus infection.

Harvesting

Satisipero *et al.* (1954) and Singh (1960) observed that under favourable conditions 2-3 harvests of leaves could be done in first year, while in second year two harvests can be done. It was observed that late harvesting (middle or

late October) of leaves reduced the second year yield, it was so because the growth of stem gets inhibited. In India, during harvest the leaves are picked manually. Larger leaves should be picked first (Srivastava and Johari, 1995). Usually, at a time 75% of leaves/plant are harvested.

Yield

The foliage yield is 152 q/ha on fresh weight basis. On dry weight basis the foliage yield in Solan (HP) is 31 q/ha and in Kodaikanal (TN) it is 28q/ha. The glycoside content was found to be less in Kodaikanal harvest than that of Solan.

Processing

Leaves should be dried in sun at 30–40°C temperature. The temperature higher than this will reduce its quality and potency. The moisture of leaves should be reduced to six percent. Once the leaves are dried it should be kept in airtight place (polythene bags) at cool and dry place. The leaves are hygroscopic in nature and thus the total glycosides content in the leaves is liable to be deteriorated if exposed to moist air.

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Medicinal yam

(*Dioscorea floribunda* Mart. & Gal.)

Medicinal yam (Dioscoreaceae) is also called Greater Yam. It originated in Central America. In India, *Dioscoria floribunda* is successfully growing in Karnataka, Asom, Meghalaya, and Goa (Farooqui and Sreeramu, 2001). Other than India it is distributed in Africa, Europe, Mexico and South America.

Plant description

It is a twining herb. The stem is glabrous and left twining. Leaves are alternate, have broadly ovate or triangular ovate, shallow or deeply cordate, coriaceous lamina with nine nerves. The petioles are 5–7 cm long, thick and firm. Variegation in leaves occur in varying degree. The male flowers are solitary and rarely in pairs. Female flowers have divericate stigma which is bifid at apex. The capsule is obovate and seed winged all round. The tubers are thick with yellow coloured flesh, branched and grow up to a depth of 30 cm. In *Dioscorea floribunda* the buds are confined to the crown position (Selvaraj *et al.* 1972).

Genetics and breeding

The chromosome number of *Dioscorea floribunda* is 2n=18. There is need

Medicinal yam root and leaf

to produce higher diosgenin content, high tuber yield, compact tuber growth, resistance to diseases and pests and wide adaptability. Breeding of *Dioscorea* sp. has been done at Indian Institute of Horticultural Research, Bengaluru. Breeding for higher diosgenin yield and resistance to diseases and pests should be carried out.

Varieties

Three varieties of *Dioscoria floribunda* have been developed which are as follows:

- FB (C)-1: It is a composite strain from introduced clonal material from central America. It has been produced in IIHR (Indian Institute of Horticultural Research), Bengaluru. The plant grows vigorously and is almost free from pests and diseases. The yield of the tuber is 25–30 t/ha per year (1 kg/plant) from one year crop or 60 t/ha for two year crop (2.5 kg/plant). Diosgenin in dried roots vary from 2.5–3.0%.
- Arka Upkar: the variety is more diosgenin yielding clonal selection than FB (C)-1. It has dark green leaves and vigorous growth habit. The yield of tuber exceeds 60 tonnes (in two year crop) and the yield of diosgenin content is 3.5–4%.
- Pusa-1: A selection from germplasm with tuber yield of 1.5 kg/plant after 18 months. It was developed by IARI (Indian Agricultural Research Institute), New Delhi.

All these varieties are adapted to tropical and sub-tropical regions of the country. FB (C)-1 and Arka Upkar are being grown in Bengaluru, Goa, Asom and other regions.

Chemical constituents

Diosgenin, a steroid is obtained from rhizomes. Some other sex hormones, cortisomes, other corticosteroids are also found in it (Krishnan, 1995). Other sapogenins found are yamogenin, botagenin and krytogenin. In some cases minor sapogenin like pannogenin and tigogenin are also found.

Roots (tubers) are used for:

- The steroids are used for the production of corticosteroids, sex hormones and antifertility medicine (Tyagi *et al.*1997). The corticosteroids possess anti-inflammatory properties and provide relief in arthritis, rheumatism and asthma.
- Sex hormones are used in substitution therapy for deficiency in natural hormones in male and female patients. The male sex hormone, testosterone and its modifications are prescribed as anabolic agents following severe illness or stunted growth. The female sex hormones find extensive use in the treatment of gynaecological disorders. In addition to these uses it is the active ingredients in oral contraceptive pills.

Soil and climate

Heavy clay soil is not suitable. It grows well in light loam soil. Much acidic soil is not desirable. In dry season irrigation arrangement is essential. Good drainage is required.

Propagation is done vegetatively by tubers or by seeds.

Tubers propagation

50-70 gm weighing tubers are used for propagation. Within 30 days crown sprout while median and tip region sprout in 120–180 days. The use of crown piece should be done for replanting as it is more yielding than median and tip regions. Prophylactic treatment is given to the tuber with 3000 ppm benlate for 5 minutes and dusting of cut ends with 0.3% benlate powder for storage and also in field for prevention of tuber rot. The sprouted tubers are then planted in the field at spacing of 60 × 45 cm. Each hectare has 37,000 plants. After one or two year of planting the crop is ready for harvest.

Seed propagation

It is not recommended for commercial production due to variability in seedlings. The fresh seeds are sown at the depth of 6-8 mm in plastic bags filled with mixture of sand, soil and well-decomposed farm yard manure in equal proportion. Per bag two seeds are sown. The seed takes four weeks to germinate and only after 6 months it is transplanted to the field. After 2 to 3 years, the crop is ready to yield economically. Plant grown by seeds are heterozygous and not uniform.

Support for the plants

Firm support is essential for growing *Dioscorea floribunda* plants. Support of wires is preferred. Five wires of 12 gauge are arranged properly on 2.5 m long and 7 cm wide poles spaced at 5 m distance. Plants are supported on the wires.

Weeding

Field must be kept clean by weeding once in two months specially before application of fertilizer.

Manure and fertilizers

Five trucks of manure/ha is mixed with soil while field preparation. Nitrogen 340 kg, phosphorus 170 kg and potash 170 kg are recommended per hectare per year. Nitrogen should be applied in four doses.

Irrigation

In dry weather the field requires irrigation at an interval of 7-10 days.

Plant protection

- Two important pests of *Dioscoria floribunda* are aphid and red spider mite. They can be controlled by the treatment of 0.5 active ingredients of alar or kelthane.
- Damage done by leaf eating insects can be prevented by prophylactic sprays of rogor (Bammi and Randhawa, 1975) or 0.1% metasystox (Tyagi *et al.* 1976).
- In *Dioscoria* sp. the attack of mites and cutworms can be prevented by the use of kelthane (0.5%f) and aldrin dust (5%).
- In *Dioscorea* sp. the fungal diseases caused by *Cercospora remularia* and late blight by *Phytophthora infestans* were cured by dithane Z-78 (0.3%) and any copper fungicide application (Asolkar and Chadha, 1979).
- Collar rot of seedling in nursery can be controlled by brassical (0.5%) suspension.
- To prevent it from tuber rot, *Dioscorea floribunda* tuber is dipped in 3000 ppm solution of benlate for 5 min and dusted by 0.3% benlate powder in talcum.

Harvesting and processing

Harvesting of tubers is done manually by pick-axes or deep ploughing with heavy mould board plough. Harvesting of tubers in Karnataka is done during February–March when leaves turn yellow because at this time the growth retards and the season is free of inclement weather which otherwise affects harvest operations. The tubers should be washed to remove soil particles. Crown portion is separated for planting. Other portion is cut in thin pieces and dried in sunlight. Delay may cause rot. It should be stored in shade for sale.

Root yield

Tuber (fresh) yield of one-year crop varies from 25-30 tonnes/ha while it goes upto 60 t/ha in two-year, under Bengaluru conditions (Bammi and Randhawa, 1975; Chadha and Rao, 1984) at IIHR (Indian Institute of Horticultural Research), Bengaluru. Saxena and Dutta (1985) reported highest yield of 60.16 t/ha for two year crop spaced at 40 × 45 cm.

Marketing

Some medicinal companies have Dioscoria farms in Bengaluru, Goa, Ooty and other places. They also encourage nearby farmers to grow *Dioscoria floribunda* with marketing agreement. They purchase dry *Dioscoria* at the rate of rupees one per kg having one percent diosgenin. If the *Dioscoria* contain 3% diosgenin then price is rupees three per kg dry *Dioscoria*. About ₹ 16,600 per year per hectare a farmer can get with additional income of 17. 3% if he

can extract the diosgenin. An extraction machine has been innovated and patented by Regional Research Laboratory, Jammu.

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Liquorice

(*Glycyrrhiza glabra* Linn.)

Liquorice (Leguminoesae) is also called Sweetwood, Mulahathi, Jetimad, Yastimadhu, Madhukah, Jesthamadhu and Atimaturam.

It is native of the area between southern Europe to Pakistan and northern India. It is distributed in the world from 5w to 100e longitudinally. It is spread from 20 n to 50 s. It is found abundantly in western China, parts of Asia Minor, Persia, Asian republics of erstwhile USSR and Afghanistan. It is found also in some warmer parts, such as in Mediterranean region of north Africa, Spain, Italy, Yugoslavia, Greece, Syria, Hungary extending from westward to eastern parts and southern Russia (Farooqui and Sreeramu, 2001). It is also cultivated in Italy, France, Germany, Spain, China and India.

Liquorice is a perennial shrub. Under favourable condition it attains the height of about 1.2 m. The root crown gives out a number of long woody

Liquorice

stems. Leaves are compound pinnate, 13 in number, which in turn bears small ovate leaflets covered with soft hairs on the underside. Flowering shoot appears in axil of terminal and axillary leaves. Raceme of small pale blue flowers are seen at the age of two to three years. In north western and central India the flower is seen rarely because it needs 14–16 hours of daylight. Fruits are 2–2.5 cm long pods, containing 2 to 5 seeds. Root is highly branched and not too deep. There is present a short taproot with large number of rhizomes. In some cases the roots, which are left in soil, produce plants.

Varieties

- Spanish liquorice: (var. Typica, Regel. & Herd.) fetches a higher price in the market and is sweetest of all.
- Russian liquorice: (var. Glandulifera, Waldst & Kit) have sweet taste. It is accompanied by a perceptible but mild bitterness.
- Persian liquorice: (var. Boiss) is of inferior quality and produces thick, hard and lumpy roots.
- EC-111236: It is a Russian collection. EC-111236 has been released as 'Haryana Mulhati No. 1' by CCS Haryana Agricultural University, Hisar. It gives 70–80 q/ha of roots at age of 3 years with 7.5% glycyrrhizic acid.
- EC-2195: It has been identified as a good strain by All India Coordinated Research Project on Medicinal and Aromatic Plants.

Chemical constituents

Main chemical constituents are glycyrrhizin, glycyrrhetinic acid, phenol, triterpenoids and saponin. The extract from underground stems, roots contains 5 to 20% saponin, i.e. glycoside glycyrrhizin. It also has caumarine compounds, herniarin, umbelliferone and flavours liquiritin, liquiritigenin, isoliquirtin and isoliquiritigenin. The glycosides, liquiritoside and isoliquiritoside are also present. A volatile flavour component is also isolated from *G. glabra* var. Glandulifera. A steroid estrogen, possibly estiol is also reported.

Parts used: Roots and underground stem.

Medicinal uses

- In ayurved and unani medication it is used as demulcent, mild laxative and expectorant.
- In modern medication it is used in bronchial tablets and cough mixtures. It is an important constituent of all cough and catarrh syrups, throat lozenges and pastilles.
- Deglycyrrhized roots are used in treating intestinal and peptic ulcers.
- The glycopeptide, synthesized from glycyrrhizic acid isoliquirategenin,

prevent diabetic related complications.

- Its consumption promotes retention of water, sodium and chloride ions in body fluid and is given to sustain thrust.
- It is anti-inflammatory, analgesic and anticonvulsive in property.
- It is now being extensively used in confectionary and tobacco blending. Also the extract gives sparkle and aroma to beer.
- Conditions of adrenal inefficiency are treated well with it.
- It is an immune activity enhancer and liver detoxifier.
- It has reproductive enhancing and healing property, good for digestion and energizer, as also it is a lung tonic.
- Glycyrrhizin inhibits the growth of human viruses and bacteria.
- Saponins can increase antibody production and interferon production.
- Liquorice triggers liver enzyme, which reduces tumour-promoting estrogen.

Cultivation technology

The soil best suited for it is loamy soil of light texture with pH 6 to 8.2, even deep moist soil, particularly on the bank of rivers, subjected to periodical inundation, is also suitable. Liquorice can also withstand salinity. Plant grows well in warm, dry and subtropical climatic conditions with well-defined winters. The plant growth is adversely affected by heavy rainfall and frost.

The propagation can be by stolons or by seeds. 60% of seed germination was reported by Punia *et al.* (1986). The stolons having two or three buds of 15 – 25 cm length can be used to raise new plant by planting it 6 – 8 cm deep in the soil at spacing of 90 × 45 cm (Legha and Sharma, 1993). The cuttings begin to sprout in 15 – 20 days after planting. From this 60 –70% of sprouting is seen. Fresh plantation can be raised during February – March or July – August. The former is preferred where irrigation facilities exist. Under the All India Crop Research Project on Medicinal and Aromatic Plants at Anand, Patel *et al.* (1991) have reported good crop stand on plantation of cuttings any time between October to mid January but October to mid November month planting is reported to be most suitable time, which avoids root rot incidence which otherwise is reported to cause large gaps in the plantation and inflict heavy crop losses. Irrigation, interculture, weeding, manuring and plant protection should be attended on time.

Plant protection

- Cercospora leaf spot: The disease is caused by *Cercospora cavarae* (P. and D. Saccarado). For controlling it, Diathane M-45 or Diathane Z-78 at the rate of 0.2% is recommended. Bavistine (0.1%) with Deltan (0.3) also finds control over the disease.
- Root rot, collar rot and wilting: These diseases are caused by a group

of fungi, i.e. *Rhizoctonia bataticola, Sclerotium* sp. and *Fusarium* sp. To prevent it Bavistin or Benlate is mixed with soil before planting. Carbendazin 0.05% though being costly as well as uneconomical can control the disease.

(c) Leaf spot disease: It is caused by *Alternaria tensuis* (Khadr and Abdel Karer, 1974). For the treatment, Cuprox or Blitox (0.2%) is sprayed 3–4 times at an interval of 6 days after the disease appears.

(d) Insect pests: For termites the soil is treated with insecticides, during field preparation. Cotton ash weevil is controlled by the use of Metasystox.

Harvesting

The crop is harvested in winter, i.e. November or December. During this time of harvest high amount of glycyrrhizic acid is present. During harvest the root contain 50–60% moisture and so should be dried for 2–3 days in the sun and then in shade for 10–12 days. Not more than 10% of moisture should be present in the dried root. They are then cut into convenient size packed in polythene bags so as to prevent reabsorption of moisture.

Yield and price

The yield of plant at two and a half or 3 years of age becomes high (proved in Haryana). The yield of dry root at Hisar (Haryana) is recorded between 70 – 80 q/ha. At Anand, 18 to 20 month crop has given an average yield of 20 – 25 q/ha. Liquorice as a whole is sold at the rate of 120 Rs/kg. Root powder is sold at the rate of 125 Rs/kg.

Scope for future development

- There is need to collect and evaluate germplasm of *Glycyrrhiza glabra* and its related species from different countries.
- The breeding programme should be carried out to get higher yield, and also for resistance to diseases and pests with high production of glycyrrhizic acid.
- Control measures for soil borne diseases should be studied in detail.

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Hops

(*Humulus lupulus* Linn.)

Hops (Cannabinaceae, Duke 1983) is also called Common hops

Origin and distribution

Native to Europe and western Asia, now cultivated in North and South America, Africa, Asia and Australia. Naturalized in many areas ranging from wet to subtropical dry forest zones. Hops is reported to tolerate annual precipitation of 3.1 to 13.7 cm, annual temperature of 5.6 to 21.3°C and pH of 4.5 to 8.2 (Duke, 1978,1979). It is suitable between latitudes 35–51°N and 34–43°S, with mean summer temperatures of 16–18°C. Hops are quite hardy. When dormant, they withstand freezing, however, a severe frost will kill young, tender vines. Annual rainfall requirement is about 30 cm, distributed between July and November.

Hops

Description of plant

Perennial herbaceous vine, living 10–20 years, with horizontal and vertical roots. The horizontal roots spreading out at depth of 20–30 cm and giving rise to fibrous roots in upper layers of soil. The vertical roots developing downward to depth of 152 cm with spread of 183–244 cm with no fibrous roots. Stem is slender, climbing, up to 9 m in length, often with stout hooked hairs. Leaves are opposite, cordate, 3- to 5-lobed. Margins serrate. Petiole is slightly fleshy with stout hooked hairs. Plants are dioecious with unisexual flowers on separate plants. Occasionally, monoecious plants occur, in which case male or female flowers are often infertile. It is wind-pollinated. Female inflorescence is cone-like, 2.5–5 cm long. Male flowers are long raceme. Many varieties are available. Morphological studies indicate that Japanese, European and American plants may be characterized by their hairy behavior at node part of stem. Varieties may also be classified into early, mid-season, and late. Some triploid varieties grown in Europe are seedless. Resin content is controlled by many pairs of genes. Disease resistance is found in some tetraploids. Most countries export and import hops for a variety of beer flavors. Cultivars vary also as per harvest time, susceptibility to downy mildew, characters of vine, lobes of leaf, number of nodes, colour of young shoot (red, violet or pale green), thickness of stem and characters of cone (size, weight, number of bracts), total resin and yield per ha. Some of the better known cultivars being grown in the world today include Italian Wild Type Humphries, EarlyCluster, Saaz, Shinshuwase, Early Green Dauba, Japanese Wild Type, Hallertau, Early Zug, Canadian Wild Type, Spalt, Fuggle American No. 2, Sappo, American Wild Type, Sonoma, Riverside, English Cluster and B.C. Goldi. In Japan about 96% of the hops crop is grown from the variety Shinshuwase.

Chemistry of hops

According to the Wealth of India (1976), hops contain 6–12% moisture, 11–21% resins, 0.2–0.5% volatile oils, 2–4% tannins, 13–24% protein, 3–4% fructose and glucose, 12–14% pectins, and 7–10% ash. According to Leung (1980) hops contain 0.3 to 1% volatile oil; 3 to 12% resinous bitter principles composed of a-bitter acids and b-bitter acids. Some other resins are oxidation products of the a- and b-acids; xanthohumol; flavonoid glycosides; phenolic acid; tannins; lipids; amino acids; estrogenic substances etc.

The volatile oil is made up mostly of humulene, myrcene, b-caryophyllene, and farnesene, which together may account for over 90% of the oil. Other compounds number over 100, including germacratriene, a- and b-selinenes, selina-3, 7-diene, selina-4, 7-diene, a-copaene, a- & b-pinenes, limonene, p-cymene, linalool, nerol, geraniol, nerolidol, citral, methylnonyl ketone, other oxygenated compounds, 2,3,4-trithiapentane, S-methylthio-2-methylbutanoate, S-methylthio-4-methylpentanoate, and 4,5-epithiocaryophyllene (Leung,

1980). Buttery and Ling (1967) compared 5 cvs for 76 of their volatile oil components. Countering claims that the "wonder cure" GLA (gamma-linolenic acid) is found only in mother's milk and evening primrose, the USDA lab at Peoria has reported that GLA was also in hops.

Toxicity of hops

Dermatitis has long been recognized not only on hands and face, but legs have suffered purpuric eruptions due to hop picking. Although only 1 in 3,000 workers is estimated to be treated, one in 30 is believed to suffer dermatitis (Mitchell and Rook, 1979).

Medicinal and other uses

- Hops are grown, solely for the brewing industry (Bradford, 1979). Bitter substance obtained from glandular hairs are used by brewers for giving aroma and flavour to beer.
- Hops is known for preservative value. There is one German patent for adding hops to sausages as a "natural" preservative. Substance prevents gram-negative bacteria from growing in the beer.
- Amount of essential oil varies from 0.2 to 0.5%. Oil of Hops also used in perfumes, cereal beverages, mineral waters, and tobacco.
- Stems are source of fibre like soybean stalks, cotton stalks, flax shives and similar agricultural residues have been suggested for pulp or biomass production. Fibre has relatively high lignin and low pentosan content, with a cellulose content lower than any of them. Sometimes used for filler material in corrugated paper or board products, but unsuited for corrugated paper because of low pulp yield for production of high-grade pulp for speciality paper.
- Young tops are used as a vegetable, especially in Belgium. Romans eat the young shoots like asparagus. Chopped very fine and dressed with butter or cream the young shoots are excellent (Fernald *et al.* 1958).
- Alcoholic extracts of hops in various dosages have been used clinically in treating numerous forms of leprosy, pulmonary tuberculosis, and acute bacterial dysentery, with varying degrees of success in China. Hops extracts are said to have various biological activities (antimicrobial activities due to the bitter acids, especially lupulone and humulone) and sedative effects.
- Extracts are used in skin creams and lotions, in Europe, for alleged skin-softening properties.
- Extracts and oil are used as flavoring in nonalcoholic beverages, frozen dairy desserts, candy, baked goods, gelatins, and puddings, with the highest average maximum use reported for an extract used in baked goods (Leung, 1980).

- Flower heads have been used to produce a fine brown dye (Grieve, 1931).
- Hop vines have 26.2% lignin as compared to 16.8% in wheat straw; cellulose 42.4% as compared to 54.7% in wheat. The stubble as well as the hop residues, after processing, could, of course, be channelled into energy production.
- Dried strobili used medicinally as a bitter tonic and sedative.
- The decoction from the flower is said to be remedy for swellings and hardness of the uterus.
- The dried fruit, used for poultices and fermentations, is said to control painful tumors.
- The pomade made from it is said to remedy cancerous ulcerations (Hartwell, 1967–1971).
- It is reported to be antiseptic, diuretic, hypnotic, nervine, sedative, stomachic, and vermifuge.
- Hop is a folk remedy for bruises, cancer, cramps, cough, debility, delirium, diaorhea, dyspepsia, fever, fits, hysteria, inflammation, insomnia, jaundice, nerves, neuralgia, rheumatism, and worms (Duke and Wain, 1981).
- Moerman (1982) gives interesting insight on uses of the plant. In India small bag of leaves are heated to apply for earache or toothache.
- Use of hops as a sedative, drinking hops tea several times a day to alleviate nervousness.
- The antibiotic principle lupulone is tuberculostatic (Duke, 1972).
- The spent hops are often used as fodder or manure.

Cultivation technology

Hops do well over a wide range of soils provided they are fertile and moisture-holding. Light to heavy loams are best. Soil depth of 45 dm is required. Plants are propagated from seed which require dormancy period for germination. More frequently propagation from layering or cuttings from established stocks is done. Spacing of 2 m × 2 m is given. Various types of pole training are used. Fertilization requirement depends on soil type and variety of hop planted. Green manure often sown in June- July and ploughed under to provide organic matter. Vegetative and reproductive growth of hops three years or older seem to be improved by pruning. Irrigation should be practiced as per need. Hop cultivations in Japan and elsewhere are usually conducted by contract system between beer company and grower.

Diseases of hops

Many fungi cause diseases in hop plants: *Armillaria mellea*, *Ascochyta humuli*, *Cercospora cannabis*, *Cercospora humuli* (Downy mildew),

Rhizoctonia solani, *Sclerotinia libertiana*, *S. sclerotiorum*, *Septoria humuli*, *S. lupulina*, *Sphaerotheca humuli*, *S. macularis*, *Typhula humulina*, *Ureolella tami* var. *humuli*, *Verticillium alboatrum*, *V. dahliae*, *V. tricorpus*, *Botrytis cinerea* (Gray mold).

Bacteria also attack hops, eg. *Agrobacterium tumefaciens*, *Corynebacterium humuli* and *Pseudomonas cannabina. Cuscuta europaea* also *parasitize* the plant.

Viruses known to attack hops include: Chlorotic disease, Chloritic mosaic, Fluffy tip, Mosaic, Nettlehead-Humulus virus 2, and Split-leaf blotch.

Nematodes isolated from hops include: *Ditylenchus destructor, Heterodera humuli, Meloidogyne hapla, M. incognita*, and *M. javanica*, (Golden, P.C. 1984).

Injury by aphids and spider mites (Tetranychus) may be serious.

Harvesting of hops

Dry weather is best for harvest. Hops are usually picked by hand. However, more recently, picking machines weighing about 160 kg are able to pick 8–10 kg/hr. In 5–6 days, 500–700 kg of cones can be picked from about 10 ha. Hops are collected in dry weather when they are ripe, carefully dried by artificial heat and packed in bags or bales. From bloom to harvest requires about 40 days. Sometimes hops are treated with sulfur dioxide to improve the colour and prevent change of active principle. Hops deteriorate upon aging and exposure to atmosphere. Drying is an important process as moisture content must be reduced from 80% to 6%. Kiln-drying is practiced in some humid areas.

Yields and economic viability of hops

Yields vary according to locality, climatic conditions, and variety. Average yields range from 860 to 1890 kg cones/ha. Best yielders are: English Cluster (1763 kg/ha); Shinshuwase (1664 kg/ha); American (1580 kg/ha); and American No. 2 (1546 kg/ha). Under ideal conditions up to 4,000 kg cones/ha have been produced. Principal hop-producing regions are: United States (Northwest and New York), England, Czechoslvakia, Germany, Yugoslavia, France, Belgium, Poland, former USSR and Canada. Hops are grown in many other countries also. In 1971, United States production was 23.3 million kg, averaging about $1.40/kg. United States imports about 6 million kg, mostly from Europe for different flavors. A growing amount is being marketed in extract form. Japan produces about 941,000 kg annually.

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Henbane

(*Hyoscyamus niger* Linn.)

Henbane (Solanaceae.) is also called Black Henbane, Khurasani Ajavayan, Khurassani Jamani, Khurassani Ajavana, and Parasikayavani.

Origin and distribution

Henbane is indigenous to Europe, central Asia, India and tropical Africa (Good. 1953). According to Hocking (1947) the plant originally came from Eurasia and is now distributed throughout Europe from Portugal and Greece in the south of Norway and Finland in the north. According to Julla Mortan (1977) henbane is native of Scandinavia and southern England to the Mediterranean and Siberia. It is also found in Caucasian Mountains, Iran and throughout Asia Minor. In India, it is found sparsely distributed over 2450 m elevation from Kashmir to Garhwal in north-western Himalayas (Watt, 1972). Small scale cultivation has been practiced in Srinagar valley and foothills of Uttarakhand. With the help of AICRP in Indian Council of Agricultural Research it is cultivated in central India and Karnataka to a small extent.

Henbane

Plant description

Henbane is erect, perennial herb with height of 160 cm. Leaves are simple, ovate or oblong to triangular ovate with long lamina, coarsely dentate, margin with pinnately lobed base and acute apex. The dry leaves emit strong characteristic odour and have bitter acrid taste. Flowers are pale yellow with purple veins (Farooqui and Sreeramu, 2001). The flowers are large, sessile or subsessile with 5-lobed persistent calyx and corolla. Fruit is an oblong – ovoid berry, about 1 cm long, having numerous small reniform seeds, which are brown to black in colour with fine reticulations on the seed coat. It is a long day plant. Approximately one gram of seed counts about 2000 seeds.

Varieties

- IC – 66 is a short duration (100 days) variety of *Hyocymus muticus*, yielding 25 q/ha with the total tropane alkaloids varying from 0.05 to 0.10%.
- Aela is a mutant culture of *Hyocymus niger* selected from irradiated progenies. It gives a yield of 73 q/ha. It also has high alkaloid content of 0.054%.

Chemical constituents

The major active constituent of henbane is hyoscyamine and is 90% of total alkaloids, rest are scopolamine and atropine. According to Singh and Sharma (1977) alkaloids in various part of *Hyocymus niger* are as follows:

Parts	Percentage of alkaloids (dry weight basis)
Leaves	0.04 –0.08
Flowering tops	0.07 – 0.10
Stem	0.01 – 0.025
Whole herb	0.02 – 0.03
Seeds	0.06 – 0.10

Parts used: Foliage and seeds.

Medicinal uses

The drug made from henbane is useful for the treatment of asthma and whooping cough. It provides relief from painful spasmodic conditions of the non-striated muscles, irritation, hysteria and gripping pain in intestinal disorders (Watt, 1972; *Wealth of India*, 1959). The dried leaves are smoked to get relief from asthmatic strokes (Boulos, 1983). In infants it is used to prevent fits and to ease the pain of teething. In Europe, hyocymous is used as a mydriatic, sedative and anodyne and is administered in case of earache and rheumatism.

Cultivation technology

The cultivation is brought about by either direct sowing or by transplantation of plants from nursery to the field after they are 6 weeks-old in the first week of October. The soil for maximum germination should be fine textured. This can be achieved by ploughing, cultivator and disc harrowing followed by planking. Add 15–20 tonnes per hectare of farm yard manure at the time of land preparation. In direct sowing 2–3 kg seeds per hectare are sown. The depth of sowing is 1–2 cm. The germination is seen after 7–10 days. Saxena *et al.* (1979) observed that direct sowing yielded higher herbage and total alkaloids as compared to the transplanted ones. Irrigation, interculture, weeding, plant protection should be taken care of.

Plant protection

The pests like cotton bug and aphids are controlled by spraying Endosulphan (Thiodon 35 ec at 1–1.5 l/hectare or Methyl Parathion 50 ec at 500 ml/hectare or Metasystox 25 ec at 650 ml/hectare) properly dissolved in 1000 litres of water. The spraying should be done 2–3 times after an interval of 10–15 days.

Harvesting and processing of henbane

According to Chopra *et al.* (1962) the annual crop is generally harvested on attaining 50% flowering. In case of biennial crop, during first year, the leaves are collected in late summer and in second year leaves are collected when the plant is flowering.

According to Maheshwari *et al.* 1984, the *Hyocymus niger* is harvested after 90 –100 days of sowing. During harvest, first the lower leaves are picked and then upper leaves along with soft twigs are collected for obtaining high yield of alkaloid.

The pickings are sun-dried. the herbage contains 80–90% of moisture, which needs to be dried fully (Maheshwari,1995). After drying they are packed in gunny bags and kept in cool dry place.

Yield

Comparitive performance of direct sown and transplanted crop of *Hyoscyamus niger* (Indian Drugs. 16(5); 102-104) has been expressed in following table:

Hyocymus niger	Dried herbage (q/hectare)	Alkaloid content (hyoscyamine%)	Alkaloid yield (kg/hectare)
Direct sowing	15.0	0.0870–0.0905	1.33
Transplanted	6.5	0.0755–0.0810	0.509

Scope for future development

Development of better yielding varieties resistant to diseases and pests.

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Jatropha

(*Jatropha curcas* Linn.)

Jatropha (Euphorbiaceae) is also called Physic Nut and Purging Nut

Origin and distribution

Though native to America, the species is almost pantropical now, widely planted as a medicinal plant which soon tends to establish itself (James A. Duke, 1983). It is listed as a weed in Brazil, Fiji, Honduras, India, Jamaica, Panama, Puerto Rico, and Salvador (Holm *et al.* 1979).

Description of plant

Shrub or tree, height about 6 m, with spreading branches and stubby twigs, with a milky or yellowish exudate. Leaves deciduous, alternate but apically crowded, ovate, acute to acuminate, basally cordate, 3 to 5-lobed in outline,

Jatropha

6–40 cm long, 6–35 cm broad, the petioles 2.5–7.5 cm long. Flowers several, in greenish cymes, yellowish, bell-shaped; sepals 5, broadly deltoid. Male flowers many with 10 stamens, 5 united at the base only, 5 united into a column. Female flowers borne singly, with elliptic 3-celled, triovulate ovary with 3 spreading bifurcate stigmata. Capsules, 2.5–4 cm long, finally drying and splitting into 3 valves, all or two of which commonly have an oblong black seed, these measure 2 × 1 cm (Morton, 1977; Little *et al.* 1974). Somatic chromosome number of *Jatropha curcas* is 2n=22.

Chemistry

Per 100 g, the seed is reported to contain 6.6 g H_2O, 18.2 g protein, 38.0 g fat, 33.5 g total carbohydrate, 15.5 g fibre, and 4.5 g ash (Duke and Atchley, 1983). Leaves, which show antileukemic activity, contain α-amyrin, α-sitosterol, stigmasterol, and campesterol, 7-keto-b-sitosterol, stigmast-5-ene-3-b, 7-a-diol, and stigmast-5-ene-3 b, 7 b-diol (Morton, 1981). Leaves contain isovitexin and vitexin. From the nuts saccharose, raffinose, stachyose, glucose, fructose, galactose, protein, and an oil, largely of oleic- and linoleic-acids (List and Horhammer, 1969–1979), curcasin and arachidic, linoleic, myristic, oleic, palmitic and stearic-acids are also reported (Perry, 1980).

Medicinal and other uses

- Reported to be abortifacient, anodyne, antiseptic, cicatrizant, depurative, diuretic, emetic, hemostat, lactagogue, narcotic, purgative, rubefacient, styptic, vermifuge, and vulnerary. Physic nut is a folk remedy for alopecia, anasorca, ascites, burns, carbuncles, convulsions, cough, dermatitis, diarrhea, dropsy, dysentery, dyspepsia, eczema, erysipelas, fever, gonorrhea, hernia, incontinence, inflammation, jaundice, neuralgia, paralysis, parturition, pleursy, pneumonia, rash, rheumatism, scabies, sciatica, sores, stomachache, syphilis, tetanus, thrush, tumors, ulcers, uterosis, whitlows, yaws, and yellow fever (Duke and Wain, 1981; List and Horhammer, 1969–1979).
- In South Sudan, the seed as well as the fruit is used as a contraceptive (List and Horhammer, 1969–1979).
- Latex applied to treat bee and wasp stings (Watt and Breyer-Brandwijk, 1962).
- Mauritians massage ascitic limbs with the oil.
- Cameroon natives apply the leaf decoction in arthritis (Watt and Breyer-Brandwijk, 1962).
- Colombians drink the leaf decoction for venereal disease (Morton, 1981).
- Bahamans drink the decoction for heartburn.
- Guatemalans place heated leaves on the breast as a lactagogue.

- Cubans apply the latex in toothache.
- Colombians and Costa Ricans apply the latex to burns, hemorrhoids, ringworm, and ulcers.
- Venezuelans take the root decoction for dysentery (Morton, 1981).
- Seeds are used also for dropsy, gout, paralysis, and skin ailments (Watt and Breyer-Brandwijk, 1962).
- Leaves are regarded as antiparasitic, applied to scabies; rubefacient for paralysis, rheumatism; also applied to hard tumors (Hartwell, 1967–1971).
- Latex used to dress sores and ulcers and inflamed tongues (Perry, 1980).
- Seed is viewed as aperient; the seed oil emetic, laxative, purgative and for treatment of skin ailments.
- Root is used in decoction as a mouthwash for bleeding gums and toothache. Otherwise used for eczema, ringworm, and scabies (Perry, 1980; Duke and Ayensu, 1984).
- Homeopathically used for cold sweats, colic, collapse, cramps, cyanosis, diarrhea and leg cramps.
- According to Ochse (1980), "the young leaves may be safely eaten, steamed or stewed." They are favored for cooking with goat meat, said to counteract the peculiar smell.
- Pounded leaves are applied near horses eyes to repel flies.
- The oil has been used for illumination, soap, candles, adulteration of olive oil, and making Turkey red oil.
- Nuts can be burned like candlenuts (Watt and Breyer-Brandwijk, 1962).
- Mexicans grow the shrub as a host for the lac insect.
- Ashes of the burned root are used as a salt substitute (Morton, 1981).
- Agaceta *et al.* (1981) reported that it has strong molluscicidal activity.
- Duke and Wain (1981) list it for homicide, piscicide, and raticide as well.
- The latex was strongly inhibitory to watermelon mosaic virus (Tewari and Shukla, 1982).
- Bark used as a fish poison (Watt and Breyer-Brandwijk, 1962).
- Sap stains linen and can be used for marking (Mitchell and Rook, 1979).
- Little, Woodbury, and Wadsworth (1974) list the species as a honey plant.
- According to Hartwell, the extracts are used in folk remedies for cancer.

Toxicity of *Jatropha curcas*

- The poisoning is irritant, with acute abdominal pain and nausea about 1/2 hour following ingestion. Diarrohea and nausea continue but are not usually serious. Depression and collapse may occur, especially in children.

- Two seeds are strong purgative. Four to five seed are said to cause death, but the roasted seed is said to be nearly innocuous.
- Bark, fruit, leaf, root, and wood are all reported to contain HCN (Watt and Breyer-Brandwijk, 1962).
- Seeds contain the dangerous toxalbumin curcin, rendering them potentially, fatally toxic.

Energy application

The clear oil expressed from the seed has been used for illumination and lubricating, and more recently has been suggested for energetic purposes, one ton of nuts yielding 70 kg refined petroleum, 40 kg "gasoil leger" (light fuel oil), 40 kg regular fuel oil, 34 kg dry tar/pitch/rosin, 270 kg coke-like char, and 200 kg ammoniacal water, natural gas, creosote, etc. In a startling study, Gaydou *et al.* (1982) compared several possible energy species with potential to grow in Malagasy. Oil palm (*Elaeis guineensis*) was considered energetically most promising as shown in the table.

Plant	Crop production MT/ha	Fuel production/ ha	Energetic kwh/ha equivalent
Elaeis guineensis	18–20	3,600–4,000	33,900–37,700
Jatropha curcas	6–8	2,100–2,800	19,800–26,400
Aleurites fordii	4–6	1,800–2,700	17,000–25,500
Saccharum officinarum	35	2,450	16,000
Ricinus communis	3–5	1,200–2,000	11,300–18,900
Manihot esculenta	6	1,020	6,600

Climate and soil requirements

Climatic requirement range from tropical very dry to moist subtropical wet forest zones. Physic nut is reported to tolerate annual precipitation of 4.8 to 23.8 cm (mean of 60 cases = 14.3) and annual temperature of 18.0 to 28.5°C (mean of 45 cases = 25.2). It can be cultivated in a variety of soil. However water logging should be avoided.

Cultivation technology

Grows readily, from cuttings or seeds. Cuttings strike root so easily that the plant can be used as an energy-producing living fence. The field is prepared by moldboard ploughing, harrow, cultivator and planking. Fifteen cart loads of farm yard manure/hectare is mixed with the soil during last phase of field preparation. Saplings 30-40 cm high from good *Jatropha curcas* tree are planted at a distance of about 7 meter plant to plant and row to row during start of rainy season. In absence of rain initially irrigation is done at an interval of about 2-3 days. After establishment of plants interval should be increased to

10-12 days. Later on it may be enhanced to one month. Interculture and weeding should be done once in two months to keep the field clean. Plant protection measures should be taken up.

Diseases

Agriculture Handbook No. 165 lists the following as affecting *Jatropha curcas*: *Clitocybe tabescens* (root rot), *Colletotrichum gloeosporioides* (leaf spot), and *Phakopsora jatrophicola* (rust). These diseases can be controlled by spraying proper fungicides.

Harvesting

For medicinal purposes, the seeds are harvested as needed. For energy purposes, seeds might be harvested all at once, the active medicinal compounds might be extracted from the seed, before or after the oil, leaving the oil cake for biomass or manure.

Yields and economics

According to Gaydou *et al.* (1982), seed yield is about 6–8 t/ha with about 37% oil. They calculate that such yields could produce the equivalent of 2,100–2,800 litres fuel oil/ha. In Madagascar, they have about 10,000 ha of purging nut, each producing about 24 hl oil/ha for a potential production of 240,000 hl (Gaydou, *et al.* 1982).

Scope of development

Development of high yielding variety having biotic and abiotic resistance.

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Opium Poppy

(*Papaver somniferum* Linn.)

Opium poppy (Papaveraceae) is also called White Poppy, Afim, Posta, Gasagase, Gashagasha, Postaka, Aphiphen, Post and Afim.

Origin and distribution

Opium poppy is native to Asia Minor and indigenous to Mediterranean region (Atal and Kapur, 1977). According to Bentley and Trimen (1992) the home of the plant is south–eastern Europe. The plant is found distributed throughout Europe, Asia, north western Africa and north America. In India it is distributed in some parts of Uttar Pradesh, Madhya Pradesh and Rajasthan. Distribution of the plant is also reported in Argentina, Bulgaria, China, Czechoslovakia, Egypt, Germany, Greece, Holland, Hungary, Iran, Japan, Poland, Portugal, Spain, Turkey, USSR and Yugoslavia (Farooqui and Sreeramu, 2001).

Opium Poppy

Plant description

Opium poppy is an annual, erect herb characterized by drooping bud and grey latex. Plant is tapering, much branched, growing upto the height of about 60 cm. Leaves are numerous, closely packed, alternate, sessile, spreading horizontally 6–15 cm long, 3–6 cm broad and cordate to much divided. Flowers are large scarlet white in colour while some are lime purple or pink or may be red. Flower buds are ovoid, oblong, 15–25 mm long. Stamens are arranged in several whorls, surrounding the carpel with captiate stigma. Fruit is a capsule, 3–6 cm long, smooth and opening by pores. The dry latex obtained by scratching the capsule is called opium. Seeds are minute and grey in colour. Chromosome number of opium poppy is 2n =22.

Varieties

Researches are going on to evolve new high yielding varieties. The varieties which have been placed on the approved list and are recommended for commercial cultivation in India are as follows: -

- Brop 1 (Botanical Research Opium Poppy-1): It is synthetic variety developed at National Botanical Research Institute, Lucknow by crossing selections from Kali Dandi, Surya Pankhi and Safaid Dandi. The variety is moderately resistant to diseases and is also resistant to lodging. This variety is highly adaptable to varied agro-climatic conditions and gives higher yield than national checks. It yields about 54 kg/ha of opium and 10–13 q/ha of seeds.
- Kirtiman (NOP-4): This variety was developed at ND University of Agriculture and Technology, Kumarganj, Faizabad and was released in the year 1990. This was developed through selection from local races. Latex yield varies from 35–46 kg/ha and seed yield from 9–11 q/ha. It is suggested to do well in the areas where temperature rises early in spring season like in the eastern Uttar Pradesh.
- Chetak (U.O. 285): This variety was developed at Rajasthan Agricultural University, Udaipur. The variety was released in the year 1994. The variety is resistant to diseases and pest and lodging. The plant yields 54 kg/ha of opium and 10 –12q/ha of seeds.
- Jawahar Aphim 16 (JA – 16): This high yielding variety was developed by Jawaharlal Nehru Krishi Vishwavidyalaya (JNKV), Mandsaur (MP). The variety was released in 1984.
- Jawahar Opium 539: This high yielding variety was developed at AICRP, Mandsaur. The variety was released in the year 1997.
- Jawahar Opium Poppy 540: This high yielding variety was developed by AICRP, Mandsaur in the year 1998.
- Trishna (IC-42): This high yielding variety was developed by National Bureau of Plant Genetic Resources, Delhi. The variety is resistant to

varied climatic conditions.

- Dhola Chota Gotia: This is a dwarf cultivar, with pure white flowers and light green capsules. The capsules are oblong ovate in shape. The plant is ready for lancing after 105–115 days of sowing and matures for seed in 140 days.
- Sharma: This variety was released by the Central Institute of Medicinal and Aromatic Plants, Lucknow in the year 1983. It yields 39.5 kg of latex and 8.8 kg/ha of seeds.
- Shweta: This variety was also released with Sharma, but it is superior to Sharma. It gives average yield of 42.5 kg of latex and 7.8 kg/ha of seeds.

Chemical constituents

The major alkaloids are morphine, thebaine, noscapine and papaverine. The contents are morphine 4–21%, noscapine 4–8%, papaverine 0.8%, codine 2.5–3.5% and thebaine 1.0–2.0%. Some other alkaloids are narcotine and narceine. Some minor alkaloids are aporeine, codamine, crytopine, gnascopine, hydrocotarnine, landanine, narcotoline, neopine, oxynacotine and papaveramine. In prolonged uses it produces toxic effects which resemble the effect occurring in epidemic dropsy.

Parts used: Opium, seeds, fruits, bark, petals and milky juice from plant.

Medicinal uses

- Opium is a well know sedative, having constipating effect, so used in diarrhoea and pains in the body.
- The ointment of opium can be used as a local anesthetic in piles, etc.
- In ayurveda it is used as sleep inducing and antidiarrhoeal drugs.
- In unani medication, it is occasionally used as an aphrodisiac.
- It is used for treatment of nausea, constipation, headache and delirium.
- Its syrup is given for cough.
- The decoction is a common anodyne and demulcent fermentation when applied hot to inflammable parts, bruises, sprains and other painful affections.
- The seeds (maw seeds) are used as the medicine for birds.
- It is also used in genito-urinary diseases.
- The semi-dried oil finds use in the manufacture of paints and in artist's ink.

Cultivation technology

The techniques of cultivation of opium poppy and collection of capsules adopted in countries like Turkey, former USSR, Yugoslavia, Bulgaria, Japan, Pakistan and India, have been published in the journals and bulletins on

narcotics, United Nations, Geneva.

In India it is grown as *rabi* crop (Sala, 1997). Before seed sowing, the soil is well ploughed, pulverized and is enriched with manure. After irrigation and final ploughing the seeds are sown by conventional broadcasting method. The plant-to-plant and row-to-row spacing should not be more than 12 cm. The regular irrigation at the interval of 20 days is required. Poppy takes about 90 days to flower from the time of sowing and the capsule becomes ready for collection after about 20 days of flowering. The lancing of capsule may be done after about 15 days of flowering (Gupta, 1984; Gaur, 1987). In India, the collection of opium starts in the middle of February and extends upto April depending on the climatic conditions and time of sowing of the poppy seeds. During the time of seed sowing, they should be treated with 10% gammexine to kill cut worms, white grubs and other pests. The poppy is then soaked in water containing formalin and then it is dried in shade. The plant should be treated with fungicide by the time it develops 4 leaves. The insecticidal spraying should be done at the regular interval of 3 weeks. Also the application of soluble salts of micronutrients of manganese, boron, copper, molybdenum, zinc, iron and magnesium is recommended as foliar spray to make the plants more healthy and pest resistant.

Plant protection

- Downy mildew is caused by *Pernospora arborescens*. This can be prevented by spraying Dithane Z-78 and Dithane M-45 or Cesan at early stages of poppy.
- Powdery mildew is caused by *Erysiphae polygoni* and is controlled by the spraying of Cuman-l mixed with Wettable Sulphur (Sultaf).
- Curley leaves disease is caused by virus, which get transmitted by aphids via sap. this can be prevented by spraying Rogor or Metasystox.
- Root rot is caused by *Fusarium semitectum*, and is controlled by removing the affected plant and spraying Bavistin (1 g/l of water) or Streptocycline (4–6 g/600–800 l of water).
- *ORABANCHE PAPAVERIS* is a root parasite specific to poppy. The remedial measure is to cut the parasitic plant at the bottom.
- Aphids and jassids are prevented by spraying of the Dimecron 100.

Lancing

Lancing is the process in which incision is made on the capsule. Usually each capsule is lanced 3–4 times or may be more than that. A special type of instrument called 'nashtar' is used to lance the capsule. Generally three parallel longitudinal incisions are made after midday. Due to incision of capsule wall the latex exude out which remains on the capsules for the whole night. On coagulation the latex becomes thick and dark in colour.

Harvesting

After lancing the coagulated latex are collected. Then the opium is allowed to dry in the plant itself (Singh *et al.* 1995). This takes 15 days after the lancing is completed. In India, the capsules are plucked by hand and the seeds are separated after breaking the capsules.

Yield

The average yield of crude opium is about 25–30 kg/ha and that of the seeds is about 400–500 kg/ha.

Processing

The raw opium cultivated by farmers is dried either by prolonged heating or sun drying. The sun drying is preferred over artificial drying. The raw opium is received by district opium officer and tested for its purity and consistency.

It has been observed that no morphine is lost for first 5 days when the opium is kept at 97–98°C, but prolonged heating leads to a progressive loss of morphine. An enzyme called peroxidase is responsible for decomposition of morphine. Under moist condition, the opium gets sometimes covered with fungus but this does not affect its morphine content.

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Long Pepper

(*Piper longum* Linn)

Long pepper (Piperaceae) is also called Indian Long Pepper, Peppali,: Hipli Magadhi, Piple, Pippili and Tippil.

Origin and distribution

It is native of Indo-Malaya. It is now widely distributed in India, Nepal, Indonesia, Malaysia, Sri Lanka, Rhio, Timor and Philippines (Farooqui and Sreeramu 2001). In India it is found in Asom, Khasi Hills, lower hill of West Bengal, eastern Uttar Pradesh, Madhya Pradesh, Maharashtra and evergreen forests of western ghats in Kerala, Karnataka and Tamil Nadu. It is widely grown in Andhra Pradesh and Andaman and Nicobar islands.

Plant description

Long pepper is a semi-erect or climber shrub. It is glabrous with slender branches. The branches are often of creeping type or trailing type. Leaves are

Long Pepper

simple, alternate, stipulate and petiolate or sessile at the upper end of the stem. The leaf lamina varies in shape over the same plant. The leaf is ovate or ovate oblong, acute, most often unequal sided or unequally cordate at base while the lower ones are usually cordate. All the leaves are entire, glabrous, membranous or slightly succulent and five to seven ribbed from the base. Inflorescence is spike with unisexual (dioecious), small, densely packed flowers and form very close clusters of small greyish green or darker grey berries. The female stalk is shorter than that of male stalk, which elongates during maturation. The stalk of female spike is thick in contrast to the male spike, which is slender.

Varieties

- Gol Thippali (Ball – Round Type) in West Bengal.
- Pipal Non Sori (Maharashtra Type).
- Asali (true) and Suvali: These two common types are present in Asom.
- Viswan released in 1996 by AICRP on Medicinal and Aromatic Plants, College of Horticulture, Trichur.

Thirty-two geographical races are now maintained at the All-India Coordinated Research Project on Medicinal and Aromatic Plants, Trichur center, Kerala Agricultural University. Being semi-domesticated for over centuries in the region, selection from amongst the diverse germplasm appears to be the most practical breeding procedure for developing varieties suitable for different agroclimatic regions and cropping situations in the country. The natural genetic diversity available now in different parts of the country has to be assembled and screened for its yielding ability and adaptability to different oil and agro climatic conditions. Target character for genetic improvement includes number of spikes per plant, length and diameter of spike, green and dry weight ratio of spikes, tolerance to diseases and pests, prolonged flowering phase to get multiple harvests etc.

Chemical constituents

Alkaloids piperine (4 – 5%) and piplartin have been reported in long pepper. Other alkaloids also have been reported which are designated as piperolactam a, piperolactam b and pellitorine. These have been isolated from the cold ethanol extract of long pepper (Desai *et al.* 1988). Piper longumine (0.2 – 0.25%) is also reported in fruits.

Further purification yielded six other alkaloids which are cepharadione b, cepharadione a, cepharanone b aristolactum, all- norcepharadione b, 2 hydroxy 1 methoxy 4 and h dibenzoquinoline –4, 5 (6 h) dione.

Parts used: Fruits, roots, stem, female spike (dried spikes) and leaves.

Medicinal uses

- The root is used for stomachic, laxative, anthelmintic, carminative, improves the appetite, useful in bronchitis, abdominal pains, diseases of spleen and tumours.
- The ripe fruit is sweetish, pungent, heals stomach, aphrodisiac, laxative, diarrhoeic and antidysentric.
- In ayurveda, it is used for treating 'vata' and 'kapha' asthma, abdominal complaints, bronchitis, leucoderma, fevers, tumours, urinary discharges, piles, diseases of the spleen, pains, inflammations, leprosy, insomnia, hiccoughs, jaundice, and tuberculous glands.
- The root and fruit both are used in lumbago and gout.
- In unani system, the fruit is used as the tonic of liver, for stomachic, emmenagougue, abortifacient, aphrodisiac, diuretic, digestive, general tonic, useful in inflammations of the liver, pains in the joint, lumbago, and night blindness.
- It is prescribed after parturition to induce the expulsion of the placenta.
- The dried immature spike and the matured root in the form of decoction are extensively used in acute and chronic bronchitis and cough for getting gradual relief.
- Long pepper with ginger, mustard oil, butter milk and curds make an ointment for sciatica and paralysis.
- The roasted spikes are beaten up with honey and are given for treating rheumatism in Konkan (Maharashtra).
- Long pepper is a useful remedy in veterinary medication.

Cultivation technology

The propagation is done only via suckers or rooted vine cuttings. It is not propagated by seeds. The suckers or rooted vine cuttings are raised in the nursery during March and April after rainfall. The rooted vine cutting as well as suckers give almost 100% of plantation. The plant needs to be irrigated every alternate day but excess moisture can cause Phytopthora wilt. The cutting is ready for field plantation by end of May. The field where the cutting is to be planted is ploughed twice or thrice and planked to make it level. The pits are dug at spacing of 60 × 60 cm and the soil of every pit is mixed with FYM at the rate of 100 g/pit. Per pit two sucker or two rooted cuttings are planted. The root system of a year old plant has been found to have seven primary roots with the length of 12 cm and 6 secondary roots of 7 cm length (Viswanathan, 1993).

Plant protection

- Rotting of leaves and veins is caused by *Colletotrichum* sp. Necrotic

spots and blights caused by *Cercospora* sp. These diseases can be controlled by spraying 1% Bordeaux Mixture, at the rate of one spray during May and 2 or 3 subsequent sprays during rainy seasons.

- The mealy bugs attack affects roots and also shows stunted growth. This can be prevented by application of insecticides like Rogor. *Piper longum* is highly infected by adults and nymph of *Helopeltis theivora*. These pests can be controlled by application of neem kernel suspension at 0.25% concentration.

Harvesting

After 6 months of planting, the vines show the presence of spikes. The spikes are ready to be harvested after two months of their appearance (Viswanathan, 1995). At this time the spikes are blackish green in colour as they are most pungent at this stage. In case if they are not harvested, the spikes ripe and lead to loss of pungency to a great extent.

Yield and price

From pipali farm, yield of ten to fifteen quintals of dry fruits per hectare is obtained. The plant continues to yield up to three to five years. After five years its stem and roots are taken out and it can also be sold. A yield of two quintals of dry root per hectare is obtained. Its market rate is ₹ 15,000 per quintal. In Vishakhapatnam (A.P.) pipali farming is done mainly for root purpose.

Processing

For drying the spikes, they are exposed to sun for 4–5 days. The ratio of green spike to dry spike becomes 10: 3.5. The storage of the spike should be done in a moisture proof condition.

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Isabgol

(*Plantago ovata* Forrsk)

Isabgol (Plantaginaceae) is also called Psyllium, Ispaghula, Blond Psyllium, Spogel Seeds, Isabgul, Ishabgola, Shalkshnajira, Snigdhabya, Issabagolu and Isphogol.

Origin and distribution

Its origin is from Persia. It got distributed to the neighboring arid tracts in west Asia, westwards to Sind, Baluchistan, Spain and the Canary Islands. (Kirtikar and Basu, 1953). It is also found in southern Spain and north Africa, Canary islands, Tasmania, Australia, Mexico and Turkmenistan. Commercial cultivation in India is done in north Gujarat, southern Rajasthan, in some places of Madhya Pradesh, Punjab and Haryana.

Isabgol

Plant description

The morphology of isabgol has been explained by many authors (Post, 1933; Pilger, 1937; Kirtikar and Basu, 1953). It is a small annual plant about 30 cm tall. Tillers arise from the base of the plant. There is a rosette of leaves on each tiller. The leaves are narrow, finely acuminate, entire or distantly toothed, attenuated at base, usually 3 nerved. Inflorescence are either shorter or longer than leaves arising in the leaf axils and bear ovoid or cylindrical terminal spikes with sessile flowers subtended by a bract and arranged in a dense spiral. They number 10–15 per tiller, bracts are 4 mm long and broadly ovate, concave, membranous and glabrous, the sepals have herbaceous midrib bordered by wide, membranous wings similar to that of bracts. Corolla is colourless, but midveins are often coloured brownish or red. The lobes are narrow to broadly oval. Style and filament are colourless or pink to dark red. The style is lengthier than stamens and protogynous. Ovary is superior, 2 celled with a single ovule in each cell. Seeds are albuminous with oily endosperm and straight embryo. They are deeply concave and are broadly elliptical to ovate or boat shaped. Length varies from 2–3.5 mm and width of 1–1.5 mm. It is pale brown to moderate brown with a dull surface. The convex surface have a small and elongated glossy brown spot. This spot is surrounded by a white portion extending to the concave surface and is called husk. The concave surface has a deep cavity in the centre of the base on which is present a hilum covered with a thin membrane (Osol and Ferrar, 1960). Root is a tap root which is 20–30 cm deep with many lateral roots which are almost perpendicular to tap root.

Genetics and breeding

Genetically many mutants have been developed which include following.

Protruding corolla mutant: This mutant was originally identified by Mehta *et al.* (1976). This mutant had receptive stigma in all the florets of a spike much before anthesis.

Ball mutant: Ball mutant differs from normal in being having much branched petiole having a spike with 5–10 florets. Also the seeds are lighter having more husk as compared to that of normal. In this, the florets in the spike are modified into elongated leaves.

Wheat mutant: The spikes of mutant are similar to that of wheat so is called wheat mutant. In the spikes corolla in absent and have many sepals and remains closed even at the time of anthesis.

Horn mutant: This differs from normal in having only two florets in the axil of separate bracts (Anon.,1980). The size of plant is small and also the florets are small sized and closely borne. Due to this the removal of anthers becomes difficult (Patel *et al.* 1980). With the help of tissue culture the haploids and somoclonal variations can be developed. There

should be an attempt to breed non-shattering type of capsule and resistance to diseases and pests.

Varieties: Gujarat Isabgol 1 and 2 and sel–10 are good varieties.

Gujarat Isabgol-3 released in 2005, by Spices Research Station, SDAU, Jagudan.

Haryana Isabgol-5 released in 1989 by AICRP on Medicinal and Aromatic Plants, CCS Haryana Agricultural University, Hisar Jawahar Isabgol-4 released in 1996 by AICRP on Medicinal and Aromatic Plants, Mandsaur.

Chemical constituents

Seeds contain protein, a fixed oil, mucilage, some cellulose and traces of starch (Anon., 1968). A glycoside named aucubin was isolated from the plant and reported to be pharmacologically inactive (Chopra *et al.* 1958). A sugar called plantiose was also isolated. Seeds contain pale yellow oil (11.42%), large amount of mucilaginous matter, inorganic ash and reducing sugar. The oil contains both saturated and unsaturated fatty acids. Saturated acids are composed of 32.77% palmitic, 60.37% stearic 6.80% lignoceric acid (Pendse, 1973). The seed during extraction with water yield mucilage, its constituents are d-xylose, l-arabinose, d-galacturonic acid and l-rhamnose (Smith and Montagomery, 1959). The husk is found to have a polysaccharide with a polyxylose backbone and pectin like compound containing galactouronate and rhamnose. The composition of these basic components may vary from species to species (Salyers *et al.* 1978).

Isabgol oil is the by-product of isabgol husk and is found to have high protein with good amount of limiting essential amino acids. The content of oil is not much (8.6%), but its oleic or linoleic acid ratio (1: 27) ensures that it is good grade edible oil (Anon. 1989).

Parts used: Seeds and husk obtained from the seed.

Medicinal uses

(a) Of seeds:
- The seeds are used as the demulcent, for cooling, for inflammatory and bilious derangements of the digestive organs.
- It is used as poultice to rheumatic and gonuty swelling.
- Decoction is used for curing cough and chronic diarrhoea.
- It is used for curing dysentery and irritation of intestinal tract.
- It stimulates the intestinal peristalsis mechanically by swelling up, on coming into the contact of water and this way it relieves the chronic constipation.

(b) Of husk:
- Acts as an anti-diarrhoeal drug.

- It is good in chronic dysenteries of amoebic and bacillary origin.
- It is beneficial in treating constipation and intestinal disorders.

Both seeds and husk are used for curing the inflammation of the mucous membrane of gastro-intestinal and genito urinary tracts, ducodenal ulcer, gonorrhoea and piles. It is also used as 'cervical dilator' for termination of pregnancy.

(c) Other uses:

It is used in dying, in ice cream industry as stabilizer and also in confectionary and in cosmetic industry.

Cultivation technology

There are many steps involved from sowing of the seed till it gets harvested like tillage, clearing of the land from weeds, clods etc and making it good for perfect seed germination, sowing, adding manures and fertilizers. The plant is photosensitive. In Gujarat, sowing is done from 20 November–20 December. In Punjab, Randhawa *et al.* (1978) reported that the yield is directly affected by the date of sowing. The yield decreased when the sowing was done from 3rd week of October, but the yield decreased abruptly if the sowing was done beyond first week of December. These results matched with the results of Iyengar *et al.* (1968).

The seeds are light and small, therefore before sowing it, the seed is mixed with sufficient amount of fine sand or sieved farm yard manure. For pest control seeds are treated with some mercurial seed dresser so as to protect it from seed borne diseases. The seeds are sown by broadcast method in nursery or field and are covered by light sweeping with a broom only from one side, this is done to prevent deep burial and also to facilitate uniform germination. Irrigation, interculture, weeding, plant protection should be attended from time to time.

Plant protection

- **Downy mildew:** It is caused by *Peronospora plantaginis*. It leads to qualitative as well as quantitative deterioration of the crop (Desai and Desai, 1969). Usually the disease appears at the time of spike initiation. The disease is difficult to check since it is a seed as well as soil borne disease. Tetraploid population raised at Anand was found to be highly susceptible (Anon., 1986). In fungicides tested at Anand, the overnight seed soaking in Aureofungin (0.75%) solution coupled with 2 spraying of Aureofungin at 15 g/ha/spray controlled the disease effectively. Also the treatment of seed with Metalaxyl (5 g/kg seeds) coupled with three sprayings of Captof (0.2%) or Metalaxyl (0.05%) effectively controlled the disease (Patel, 1984). The spraying was done first after the appearance of the disease and repeated at 10 days intervals. For

preventive measures the fungicides like Bordeaux Mixture (6: 3: 100) or Copper Oxychloride or Dithane M-45 or Dithane Z-78 or any other copper fungicide at 2.0–2.5 g in 1 lit of water may be sprayed when weather for pathogens turns favourable.

- **Damping off disease:** The disease is caused by *Pythium ultimum* Trow (Chastagner *et al.* 1979), *Rhizoctonia solani* Kuhn (Anon., 1960) and *Fusarium oxysporum* Schlescht Emend. synd & Hans. (Russell, 1975). Pre-treatment of seeds with metalaxil or with fenaminosulf at 5 g/kg seeds may protect the seeding by 67% while the fenaminasulf is able to protect 78% of it, though it is found to be phytotoxic to some extent and so it delays as well as reduces the germination. The treatment with CGA 489 is effective which provides protection to young seedling for longer period.
- **Wilt:** Wilting is due to *Phythium ultimum* and *Fusarium oxysporum* (Russell, 1975; Chastagner *et al.* 1979). It comes either due to the pre-emergence damping off or as a late season wilt by *Fusasrium solani* and *F. oxysporum* reported by Mehta *et al.* (1985) from Haryana. The treatment of seed by fungicide, like Bavistin or Benlate at 2.5 g/kg of seeds has been found to protect the seedling for about a month (Russell, 1975).
- Powdery mildew: It may appear at the time of flowering (Shakhela *et al.* 1985). It is incited by *Erysiphe cinchoracearum* D.C. (Kumawat, 1979). It can be controlled by spraying Karathane W.D. (0.2%) or Wettable Sulphur compounds as soon as the disease appears (Shakhela *et al.* 1985).
- Insect pests: When white grub and termites attack it can be controlled by 65% Lindane (125 kg/ha) or 10% BHC (60 kg/ha) before last ploughing. Aphids are also found to attack this crop and are controlled by spraying 0.2% Dimethodate.

Harvesting

The crop matures during March-April approximately after 110-130 days after sowing. On maturation the seeds can be shed easily even if touched slightly and also the crop turns yellowish and spike turns brownish. During harvesting the atmosphere should be free from moisture or else it would lead to lot of seed shattering (Sriram and Dalal, 1995). Normally the whole plant is cut and is bundled in large thick cloth sheet. After 2 days they are thrashed with bullocks or tractors for easy separation of seeds from spike. The thrashing is done in early morning.

Yield

The varieties developed by Agricultural University, Gujarat, i.e "Guj.

Isabgul-1 and Guj Isabgul-2" yield 800–900 and upto 1000 kg/ha of seeds respectively. In excellent weather condition the yield may rise up to 1500 kg/ha.

Higher seed yield of 1.8 to 2 tonnes/ha are reported from experimental cultivations over medium textured fertile soils at Mandsur (M.P.) and Udaipur (Rajasthan).

Processing

In processing, psyllium seeds are cleaned by a sieve. Afterwards the seed are grounded and then for removal of husk fan and sieve are used. Afterwards proper packing is done.

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Aonla

(*Phyllanthus emblica* Linn.)

Aonla (Euphorbiaccae.) is also called Indian Goose Berry, Myrobalan, Amla, Nelli, Malakka and Amlaki.

Origin and distribution

It is said to be indigenous to tropical Asia (Singh *et al.* 1963). and found growing wild in tropical forests of India as well as on the hill slopes up to an elevation of 4000 feet. It also grows wild in some of the south Indian forests. District Pratapgarh in Uttar Pradesh is famous for development and production of this fruit in the whole world. *Aonla* is being cultivated in various states of north and south India.

Aonla

Description of plant

It has height of 20 to 20 ft. Usually it is evergreen throughout the year (Anand Singh *et al.* 2004). Bark is smooth. Fruit is smooth and nearly stalk less. Fruit is hard and divided into six segments. The fruit has one hexagonal stone having six seeds. Fruits skin is thin, the flesh taste acidic sweet.

Varieties

- *Banarsi Aonla*: It is excellent variety. It's fruit size is large, colour yellow and shining. Yield is also very good for nearly thirty-five years.
- *N.A. 6, 7 and 10*: These varieties were developed by Acharya Narendra Deo University of Agriculture and Technology, Faizabad, Uttar Pradesh. All these are good and high yielding varieties of *Phyllanthus emblica* Linn.
- *Anand-2:* It was developed by Gujarat Agricultural University, Anand as good high variety for Gujarat.
- *BSR – 1*: It is also a good and high yielding variety.
- *Chakia*: It was developed in Pratapgarh (Uttar Pradesh) as superior variety.
- *Kanchan*: It is a high yielding selection from Uttar Pradesh.

Chemical constitution

Aonla fruit is well known for its very high vitamin C content. It is 20 times more than in mandarin fruits. One hundred gram of *Aonla* flesh has 1220 to 1814 milligram vitamin C (Pahuja, 2003)

Part used: Fruits, leaves, seeds and roots.

Medicinal and other uses

- *Aonla* is widely used in ayurvedic medicines such as Chawanprash, Amritkalsh, Murabba, Kayakalp, pickles, Trifla (mixture of aonla, harad and bahera), hairtonic etc.
- Leaves, seeds and roots of *Aonla* also have several medicinal uses.
- *Aonla* fruits can be used to prepare wine (Raviprasad Kamila, 2007)

Because of its diversified uses it is known equivalent to Tridev (Bramha, Vishnu and Mahesh) in Ayurveda according to Pahuja 2003.

Cultivation technology

For commercial purpose it should be never propagated by seed because seed propagated trees are usually inferior. Shield budding is the best method to propagate *Aonla* plants. Seeding trees can be improved well by top working with scion of a good variety.

Pits measuring 60 cm × 60 cm are made at distance of 10 meter × 10 meter in well prepared field. Pits should be filled up by a mixture of compost and

soil (1: 1), in the month of June. By irrigation or rains the mixture get settled. In beginning of July, saplings of *Aonla* should be planted in the afternoon. Each hectare accommodates 100 tress. After planting, the saplings must be irrigated. During rainy season if it does not rain then the field must be irrigated once in ten days, 7 to 10 days duration is followed during winter. In summer the duration should be 3 to 4 days. From second year to sixth year irrigation should be given in 10 to 30 days depending upon the need. Application of about 10 kilograms of farmyard manure per plant before onset of monsoon is recommended. Before flowering addition of 3 to 4 kg of super phosphate results in better yield of fruits.

Protection from pests and diseases

No serious pest or disease damages *Aonla*. During August-September caterpillars of an insect *Benfonsa stylophora* occasionally makes bores in branches and hide there. If it is near the tip then growth is hindered. Affected parts get swelled. For control measure entomologist should be consulted. Planting 91.44 cm height of stem with bordo paste keeps the trees healthy

Harvesting and yield

Flowering starts by end of February (Pathak, 2003). From seventh year *Aonla* tree starts production of fruits. During winter the fruits attain harvesting stage in south India. At some places *Aonla* is available throughout the year. To harvest, person climbs the tree and plucks the matured fruits and keeps in the bag. Yield per tree is about 200 and 300 kg of fruit. Per hectare about 200 to 300 quintal fruits are obtained. Till 35 years the tree yields well every year.

Economic viability

Aonla sells for about ₹ 18 to 30 per kilo. This way gross income of ₹ 3.6 lakh to 9.0 lakh/ha is possible. If half of this is deducted as cost even then 1.8 lakh to 4.5 lakh/ha net profit is possible. If the fruits are sold at ₹ 10 per kilo even then gross profit of ₹ 2 to 3 lakh per hectare can be obtained. Details of expenditure and income shows that during seventh year net profit of ₹ 7,2850/ ha and from eighth year to 35 years every year a net profit approximately ₹ 2,62,000/ha can be obtained. Main marketing centers of *Aonla* in India are located in Mumbai, Amritsar, Kolkata, Patna and Hyderabad. *Aonla* is exported from India to USA and Gulf countries.

Increase in area under aonla cultivation

District Pratapgarh located in Uttar Pradesh is famous for high quality of *Aonla* throughout the world (Chadha, 2003). It is being cultivated in other states of north India. Eighty percent of Indian *Aonla* is being produced in Uttar Pradesh and nearby places. Because of increasing demand for wide use

in herbal medicines its area is increasing to Gujarat, Maharashtra, Madhya Pradesh and south India. Now *Aonla* is being cultivated in 30,00 hectares. Out of this 1200 hectares are in Tamil Nadu alone. Every year 75 hectares are being added for its cultivation there. Another reason for increasing area is development of suitable varieties. Waste land can be utilized for its cultivation. Increase in its area has resulted in increase in rural employment. For development of *Aonla* in India an organization entitled "*Aonla* Growers Association of India" has been established in Tamil Nadu located in Selam.

Addresses to get Aonla plants

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2. Head, Department of Horticulture, Acharya Narendra Deva University of Agriculture and Technology, Narendradev Nagar P.O. Faizabad, U.P., Phone: 05272 –2163.
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Sarpagandha

(*Rauvolfia serpentina* (Linn.) Benth ex. Kurz]

Sarpagandha (Apocynaceae) is also called Serpentina root, Serpentine, Rouwolfia root, Chandrabhaga, Chota Chand, Sarppaganti, Chivan Amelpodi. Harkaya, Harki, Sutranav, Sarpagandhi, Talgandhi. Paatalagani, Paataala Garuda, Chundrika, Chuvannavilpori and Suvapavalporiyan.

Origin and distribution

It is indigenous to the moist, deciduous forests of south-east Asia which includes Bangladesh, Burma, Malaysia, Sri Lanka, Indonesia and the Andaman Islands. It is distributed in India, Nepal, Burma, Thailand, Bangladesh, Indonesia, Cambodia, Philippines and Sri Lanka. In India it occurs naturally in the foothills of Himalayan range. From Himalayan foothills it is distributed from Sal forest in north-west near Yamuna river, to the lower ravines of Asom and Meghalaya to the elevation of 1300–1400 m, via Shiwalik ranges of Shimla and Dehradun, eastern U.P., Bihar, Nepal, eastward of Sikkim, foothills of

Sarpgandha

Darjeeling and Jalpaiguri reserves forests of north Bengal. It is also available in Andaman Island, Western Ghats tract in Konkan, slopes of Annamalai hills of Tamil Nadu and south- west coast in Kerala state. The plant is also distributed sporadically in Andhra Pradesh, Bastar forests of Madhya Pradesh, Odisha and Chota Nagpur of Bihar (Dutta and Virmani, 1964; Sulochna, 1959). At present it is being cultivated in U.P., Bihar, T.N., Odisha, Kerala, Asom, West Bengal and Madhya Pradesh. Thailand is now the chief exporter of Rouvolfia alkaloids. Zaire, Bangladesh, Sri Lanka, Indonesia and Nepal are also small exporters (Guniyal *et al.* 1988 and Sarin, 1982).

Plant description

It is an erect evergreen perennial under shrub with a cluster of branches (2 – 6) arising from the root. Leaves are simple having short petiole, it is glandular at the base, glabrous and bright green when young but becomes pale yellow before shedding. Leaf shape is elliptic-lanceolate and occur in whorl of 3 – 5 but may be opposite, particularly at the base of the stem. Leaf apex is acute to acuminate. Inflorescence is terminal or sometimes axillary. The flowers are abundant and form an inflorescence in compact cymes, forming a hemispheric head at the end of a long peduncle. Flowers are small, pedicellate and hermaphrodite. Calyx is glabrous, five-lobed and deep red. Petals are five in number, gamopetalous and white. Corollas are tubular and swollen in the middle. Stamens are 5, epipetalous, enclosed within the dialated portion of corolla tube. Carpels are 2, connate, style filiform and stigma large. Fruits are drupe, obliquely ovoid and purplish black in colour when gets matured. Seeds are ovoid and wrinkled. The main root grows upto 40–60 cm deep into the soil. Root is prominent, tuberous, usually branched. Outer bark of the root is corky with irregular longitudinal fissures and posseses high alkaloid concentration. Thin branches have more alkaloid content.

Varieties

The evaluation of six populations from different locations was done at JNKVV, Indore and the culture was purified and designated as 'RS-1'. The variety is being commercially cultivated by the Jawaharlal Nehru Krishi Vishwa Vidyalaya, College of Agriculture, Indore.

Chemical constituents

The roots of *Rovwolfia* is reported to have more than 20 alkaloids, of these reserpine, rescinnamine, deserpidine, ajmaline, alstonine, neoajamaline, serpentine and alpha- yohimbine are pharmacologically important alkaloids. The extraction of alkaloid depends on the age of plant, the time of harvest, ecological condition of growth and also on the handling of material, ie. drying and storage.

Medicinal uses

- The roots of this plant is used as sedative, to control high blood pressure and certain form of insanity.
- In ayurvedic system of medicine, insomnia, epilepsy, asthma, acute stomachache and painful delivery of child and also high blood pressure and insanity are treated with the roots of *Rouvolfia serpentina.*
- In addition to its use as an antidote for snakebites, *R. serpentina* was often employed to treat anxiety, insomnia, and insanity. In fact, in parts of India, *R. serpentina* was known as "pagal-ka-dawa," which translates to "the insanity cure." Other local cultures are the plant used as a relaxant and as a tranquilizer to put children to sleep for the night.
- The alkaloid reserpine isolated from the root is considered a sympathomimetic agent, one that targets the sympathetic nervous system. Reserpine has been found to lower blood pressure in remarkably low oral doses. CIBA, a pharmaceutical company based in Switzerland, marketed reserpine under the trade name Serpasil as the first major drug to treat hypertension. (In 1996, CIBA combined with Sandoz Pharmaceuticals, another Swiss company, and now exists under the new name Novartis.)

Parts used: Roots, leaves and seeds.

Cultivation technology

The plant can be cultivated by root cuttings, by stem cuttings, by root stumps or by seeds as described below. The plants grow well in the places where rainfall is heavy.

By Root Cuttings: About 5 cm long root is planted in the nursery during rainy season. The beds are kept moist. Within three weeks the cuttings begin to sprout. Now these are planted in the field mostly during rainy season when around 8–10 cm of rainfall is already received. During transplantation of seedlings, the distance of 30 cm is maintained from plant to plant and also the distance of 45 cm is maintained from row to row.

By Stem Cutting: 15–22 cm long stem is planted closely in the nursery during June. The bed is kept moist. After the stem sprouts and roots are seen, the plant is transplanted. Normally 4–65% new sprouts are reported by stem cutting propagation.

By Root Stumps: In this the stem above the collar along with 5 cm of root is directly planted in the field with proper irrigation facilities.

By Seeds: Seed germination is found to be highly variable. Its germination varies from 5–30%. In that too only heavy seeds germinate, since according to Gupta (1968) light seeds consist of atrophied embryos and hence germinate very rarely. The factor like temperature, moisture, period of storage, etc. are found to effect the seed germination. In all, 6 kg of seeds are sufficient to raise

one hectare plantation.

Manuring, irrigation, interculture, weeding, plant protection etc. are attended.

Plant protection

- Leaf spot is caused by *Cercospora rouvolfiae*. This can be controlled by Dithane Z–78 or Dithane M–45 at the rate of 0.2% by spraying it in early June and should be repeated every month till November.
- *Alternaria tenuis* affects leaves, flowers and also fruits. The crop should be sprayed with 30 g Blitox in 10 lit of water when the symptoms are seen.
- Mosaic is commonly seen in the plant. For its prevention the selection of seedling at nursery stages should be done properly.
- Root knots is caused by the pest like mites, fungi or nematodes (*Heterodera* sp.). It is controlled by the application of 25 kg of 3G. Carbfuran or 20 kg Phorate granules/ha is also found to be effective.
- Pyralid caterpillar (*Glyhodes vertumnalis*) is found to affect the leaves. It can be controlled by spraying 0.2% Rogor.
- Cockchafer grubs (*Anomala polita* Blanch) attack seedling. It can be prevented by mixing phorates with the soil during nursery preparations.
- Wilt caused by *Fusarium oxysporium*. No control measure has been yet reported.
- Powdery mildew caused by *Leveillula tauriea*. For control the spraying of fungicides like Karathane or Bavistine are recommended. (i) Pests like *Diaphania nilgirica*, etc. cause damage. Research has been undertaken to find control measure.

Harvesting and processing

After 18 months of plantation, the crop is reported to produce maximum yield of root (Trivedi, 1995). At this stage the root contains maximum concentration of total alkaloids. The root bark contributes 40–45% of the total root weight. During digging out the roots, the thin roots are also collected. Then the roots are cleaned and cut into small pieces. These pieces of 12–15 cm length are then dried till its moisture reduces to 8–10%. Then these are stored in polythene lined gunny bags in cool dry place, to protect it from mould.

Yield and price

The yield of root depends on soil fertility, crop stand and management (Farooqui and Sreeramu, 2001). The average yield of root is from 15–25 q/ha of dry weight. The price of *Rouvolfia serpentina* roots powder is 2,400 ₹/kg.

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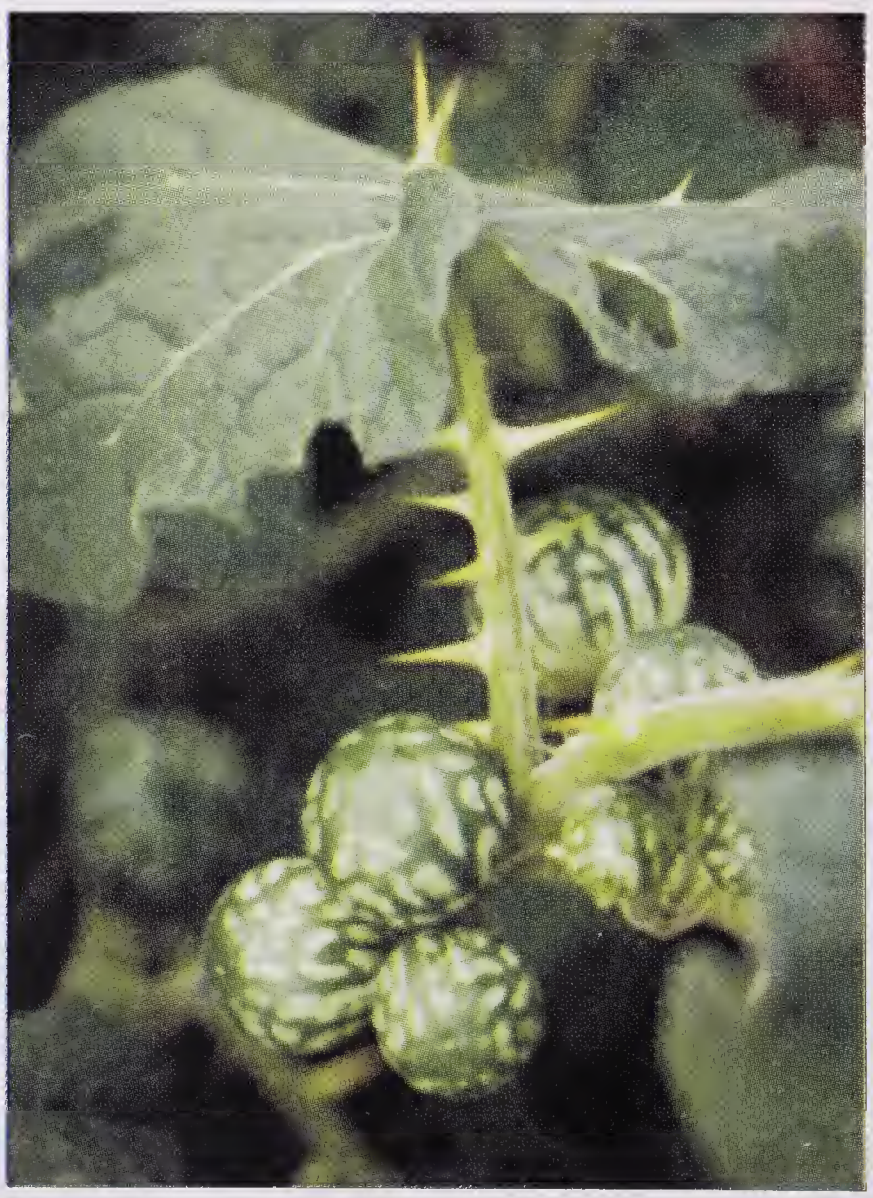
Khasi Kateri

Solanum viarum Syn. *Solanum khasianum* (Clarke)

Khasi kateri (Solanaceae) is also called steroid bearing solanum, and Kasibadne.

Distribution

Khasi kateri is distributed in India, Mynamar and China. It enjoys a wide distribution as it easily adapts to various agroclimatic conditions. Commercial cultivation under the sponsorship of Galaxo Laboratory mostly was confined to the peninsular India covering Mahbubnagar in Andhra Pradesh, Vadodara and Bulsar in Gujarat, Raichur, Hassan and Bengaluru in Karnataka and Jalgaon in Maharashtra (Farooqui and Sreeramu, 2001). In the north-eastern region, large scale cultivation of the improved RRL Jorhat strain was taken up in Diphu in collaboration with Asom Hills Development Corporation. In north



Khasi Kateri

Bengal it is being reported to be grown in tea gardens and 2000 acres are covered around Jalgaon in Maharashtra.

Genetics and breeding

At Indian Institute of Horticultural Research, Bengaluru sufficient work on genetics and breeding of *Solanum viarum* (*Solanum khasianum*) has been done. Further breeding work should be carried out to develop spineless variety having more yield of solasodine and resistance to diseases and pests.

Varieties

Originally it was spined which causes problems in crop management. To solve this problem plant breeders have produced spineless varieties which can be grown at closer spacing producing more yield of berries. Galxo strain, BARC strain, Pusa-1, RRL-20-2 and RRL-GL-6. These are less spiny varieties. Arka Sanjeevini and Arka Mahima are two diploid and tetrapoloid varieties of the crop developed at the Indian Institute of Horticultural Research, Hessargatta, Bengaluru and released for cultivation by Dr R. Krishnan (1995). These are spineless good varieties.

Chemical constituents

The plant yields glyco-alkaloid, solasodine, a nitrogen analogue of diosgenine. Solasodine through 16-dehydro-pregnenolone (16 DPA) is converted to a group of compounds like testosterone and methyl - testosterone and corticosteroids like predinisolone and hydrocortisone.

Medicinal uses

It is used as steroid. It is an ingredient of contraceptive pills, corticosteroids and sex hormones. Besides having steroidal effects it also has anti-inflammatory, anabolic and antifertility properties.

Cultivation technology

- *Raising nursery:* It is propagated by seeds. The seedlings are raised like chillies or brinjal in raised nursery. For convenience in weeding, irrigation and removing seedlings, nursery strips of 10 × 1 m are prepared. To each strip about five baskets of manure, one kg of calcium ammonium nitrate, 500 gm of aldrin or gamaxene are applied while preparing the nursery. Seeds are sown in lines at 10 cm apart and covered by thin layer of soil. About 1.25 kg of seeds sown in five such strips will produce enough seedlings for planting one hectare. Germination is completed in one week. After 3 weeks, seedlings are manured with 500 gm urea in solution. In about 5 weeks the seedlings attain height of 10-12 cm, then these are ready for transplantation.

- *Time of sowing:* It should be sown in mid March to mid April. Plants grown in rainfed fields sometimes grow better.
- *Land preparation*: Land should be prepared at least one week before planting. The field should be cross ploughed one time with mouldboard plough and then with harrow and cultivator.
- *Spacing and transplanting*: Seedlings are transplanted at 75 cm plant to plant as well as row to row. After planting light irrigation is given.
- *Manure and fertilizers:* It responds well to manure and fertilizers. In poor soils plant growth is stunted and fruiting is poor. Green manuring before planting enhances yield by 20%. Addition of 100 kg nitrogen, 60 kg phosphorus and 40 kg potash/ha gives good yield. Entire quantity of phosphorus and potash are broadcast at the time of final field preparation. The nitrogen is applied in 3 equal splits – first one after two weeks of transplanting when seedlings are established. The second after one month. Nitrogenous fertilizer is applied along rows close to plants. Then it is followed by earthing. Light irrigation after fertilizer application make the nutrients easily available to plants. Third application of nitrogen is done after 3 months of planting.
- *Weeding operations:* Fields should be kept free of weeds otherwise weeds will rob nutrients from the soil. In initial stage weeding should be done once in two months. Afterwards the canopy does not allow weed growth. Earthing also helps in weed control.
- *Irrigation:* About six irrigations are required at interval of 20 days in dry weather. This crop can not tolerate water logging.

Plant protection

- After first watering, seed beds get a drenching of 0.25% solution of copper oxychloride or of 0.1% solution of Bavistin to protect seedlings from damping off disease.
- The spray of endosulfon mixture (0.1%) should be done on seed beds to protect the seeds from biting and cutting pests.
- To prevent it from powdery mildew dusting of 4–6 kg Sulphur dust or 750 g Wettable Sulphur well dispersed in 250 of water is sprayed on one acre crop. Karathane (110 ml) or Bavistin (250 g) in 250 liters of water is also found to be effective.
- Bacterial Blight: To control this disease 12 g of streptocycline and 12 gms of Copper Sulphate be dissolved separately in 1 litre of warm water each. Then both solutions are to be added to 200 litre of water and sprayed on one acre of crop, to prevent it from bacterial blight.

Harvesting

The harvesting is to be done when the berries turn yellow. These berries are picked by hand. The fruiting is not simultaneous and so the harvesting

takes months. A labourer with gloves can pick about 50 kg berries in eight hours. In peak season one may pick as high as 80 kg in eight hours. This figure reduces to about 30 kg in end of season. Picking last for two months.

Processing of berries

Fresh solanum fruits contain about 80% moisture. Pharmaceutical companies need air dried berries containing 10% moisture. Therefore, berries are air dried in sun. To hasten drying and to impart better colour, berries are cut in two halves. However, cutting is a costly affair. Bursting fruits with wooden hammers or running a light roller also expedites drying process. Burst fruits are spread in single layer on floor and turned frequently. In bright sun drying is completed in 4 to 5 days. In cloudy days or when the fruits are kept in heaps drying is delayed. The materials turn black due to fungal attack which reduces the solasidine content. Hence the berries should be properly dried so that bright yellow material is obtained (Srivastava, 2006). Mechanical drier may be used in rainy season but this process will be expensive. When dry berries make cracking sound they are packed in bags for transport. On average 5 kg of fresh berries give one kg of dry berries.

Yield and economics

When crop is grown by adopting proper cultivation practices it may yield nearly 10,1000 kg/ha of fresh berries which, in turn will give about 2,500 kg/ha of dried berries. A profit of ₹ 5,560/ha was worked out for the strain RRl - 20–2 by Kaul and Zutshi (1997).

Marketing

Solanum berries are required by those pharmaceutical companies who manufacture drugs only from steroidal hormones. Hence it is desirable to have an agreement with pharmaceutical firms before taking up cultivation. The rate generally offered is ₹ 5/kg of air dried berries' containing 10% moisture and atleast 2% solasodine.

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Ashwagandha

[*Withania somnifera*–Dunal/(Linn.)]

Ashwagandha (Solanaceae) is also called Winter Cherry, Asgandh, Varahakarni, Viremaddinagaddi, Kiremallinagida, Amukkira & Amukkirakkilangu.

Origin and distribution

It is believed to be found wild in grazing grounds in Mandsaur and the forest lands in the Bastar districts of Madhya Pradesh and Chhattisgarh. It is distributed in Spain, Fenary Island, Morocco, Jordan, eastern Africa, Baluchistan (Pakistan), Sri Lanka and India. In India it is found in Gujarat, Madhya Pradesh, Rajasthan, western Uttar Pradesh, Punjab, Haryana, Maharashtra, West Bengal, Karnataka, Kerala and in Himalayas up to the height of 1500 mts. In Madhya Pradesh about 4000 ha of land is under cultivation of Ashwagandha. It is grown in Manasa, Neemuch, Jawad tehsil

Ashwagandha

of Mandsaur and also in Bastar district of Madhya Pradesh and Chhattisgarh state.

Plant description

Ashwagandha is an erect, evergreen, tomentose shrub. It attains the height of 30–75 cm. Leaves are simple, ovate, glabrous, opposite. Flowers are inconspicuous, greenish or dull yellow in colour, axillary, umbellate cyme and bisexual. It consists of 5 sepals, 5 petals and 5 stamens, 2-celled ovary with single style and bilobed stigma. The petals are united and tubular. The stamens are attached to corolla tube and bear erect anthers which form a close column or cone around the style. In some strains pollen production is not good. Fruit is small, berry, globose, orange or red on maturation. The fruits remain enclosed in persistent calyx. Seeds are small flat yellow, light weighed and reniform in shape. Roots are stout, fleshy, cylindrical, whitish brown in colour and not very thick.

Genetics and breeding

The chromosomal number is 2n=48. Twenty-four promising germplasm lines were studied for genetic variability at Mandsaur. Single plant selections were made in successive generations of germplasm grown at Jawaharlal Nehru Krishi Vishwavidyalaya (JNKV), Regional Agricultural Research Station, Mandsaur under Medicinal and Aromatic Plants project and evaluated for fresh and dry root yield. Seven promising lines were identified, ie. WS10, WS12, WS14, WS16, WS19, WS20, WS22. Finally WS20 was recommended for general cultivation at the All India Medicinal and Aromatic Plant workshop under popular name – Jawahar Asgandha 20 (Nigam *et al.* 1991).

Variety

Jawahar Asgandha 20, was released in 1989 from Jawaharlal Nehru Krishi Vishwavidyalaya Regional Agricultural Research Station, Mandsaur. The variety has quite high dry root yield.

Jawahar 134 was released in 1998 by AICRP on Medicinal and arometic Plants, Mandsaur.

Chemical constituents

The major alkaloid present in the root is withanine. Some other alkaloids are reported in the roots which are somniferine, somniferinine, somnine, withananine, pseudowithane, withananinine, choline, tropanol, pseudotropanol, cuscokygrene, 3- tigloyloxytropana, isopelletierine, anaferine, anahygrine, withasomnine and several other steroidal lactones. Apart from alkaloids, roots also have starch, reducing sugar, hentriacontane, glycosides, dulcital, withaniol acid and a neutral compound. The amino acid in roots includes aspartic acid,

glycine, tryosine, alanine, proline, tryptophan, glutamic acid and cystine. Leaves contain 12 different withanolids. Withaferin 'a' is most important of withanolids isolated so far. It has antibiotic and anti-tumour activities.

Parts used: Leaves, seeds, roots and bark.

Medicinal uses

- Roots are used for curing hiccups, female disorder, bronchitis, rheumatism, dropsy, stomachache, lung inflammation and skin disease.
- Leaf paste and root paste are used to relieve joint pain and inflammation.
- The root and leaves are also used in treating disability and sexual weakness in male.
- The warm leaves are used for providing comfort during eye diseases.
- Seeds are diuretic in nature.

Cultivation technology

The plant grows well in sandy loam or light-red soils with good organic matter and drainage. The pH of 7.5–8 is ideal for ashwagandha. Climate suitable for the plantation is subtropical climate. Plants also thrive well in dry climate. Only 1–2 late winter rains are sufficient for the roots to develop fully. The seeds of Asgandha are generally not used for line sowing instead they are broadcasted. The distance of about 25 × 25 cm should be kept for better cultural practices. Germination of seed takes place after 6–7 days after sowing. The sowing of crop should be done when the land is sufficiently moistened due to rainfall. Light rain after sowing is good for germination. The seed while sowing should be treated with thiram or dithane M-45 at 3 g/kg seeds so as to protect them from seed borne diseases. Organic manuring, irrigation, interculture, weeding, plant protection should be well attended.

Plant protection

- The seed borne diseases can be checked by treating the seed with dithane M-45 or thiram or deltan at 3 g/kg seeds before sowing.
- Seedling blight and leaf blight are also controlled by treating the seeds, along with one to two spray of 0.3% fytolon or dithane Z – 78 or dithane M – 45.
- The seedling mortality or die back disease can be minimized by use of healthy seeds and pre-treatment of seeds with thiram or deltan (3–4 g/kg of seeds).

Harvesting and processing

Harvesting is done after 150–170 days from sowing, which usually starts from January and continues up to March. During harvesting the entire plant is uprooted, the roots are then separated from the aerial part by cutting the stem

1–2 cm above the crown. The root is then cut into small pieces to facilitate drying. These dried roots undergo cleaning, trimming and grading before packing it for market. Berries are harvested separately, dried, beaten and seeds are taken out and stored properly.

Yield

In Madhya Pradesh the commercial crop produces 3–4 q of dried roots and 50–75 kg seeds/ha. The total alkaloid content in Indian Ashwagandha roots is reported to vary between 0.13–0.31%.

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AROMATIC PLANTS

Ambrette

(*Abelmoschus moschatus* Medik.
Syn. *Hibiscus abelmoschous* Linn.)

Ambrette (Malvaceae) is also called Musk Mallow, Mushkdana, Kasturidana, Kasturi bhindi, Kadu kasturi, Kattu kasturi, Vartlaikasturi, Gandapura, Kasurilatika, Latakusturikam.

Origin and distribution

It originated in India (Zeven & Zhukovsky, 1975). In India it is wildly distributed in the foothills of Himalayas. Other than India it is also found in south China, Indonesia, New Guinea, south-west Pacific Island, northern Australia, south-east Asia, Brazil, Columbia, Ecuador, Madagascar, Papua and Seychelles.

Parts used: Seed, seed coat, fruit, leaves, roots, bark and essential oil.

Description of plant

Ambrette is an erect herbaceous, hirsute or hispid annual or biennial herb (Farooqui and Sreeramu, 2001). The plant attains the height of about 2 m. The

Ambrette

stems are somewhat woody at base and rarely hollow. It is hispid-pubescent throughout, the hair being suppressed or present on the stems. Leaves are palmately 3-7 lobed with varying sizes of long petiole. Flowers are solitary in the upper leaf axils, on apical pedicels. Involucral bracts are 6-10, more oppressed, persistent, linear to subdulate or lanceolate. Sepals are 5 toothed at the apex and petals are yellow with a deep purple spot at the base. Fruit is a capsule, spiculate, oval to fusiform, usually five-chambered, hispid green when young, taking a reddish tinge on maturity finally turning to black on ripening. Seeds are ovoid – reinformed, black concentrically striate and pubescent with much scented smell (Srivastava *et al.* 1986).

Genetics and breeding

Chromosome number of Ambrette is 2n =72. Germplasm base in Ambrette is relatively low. In India, about 50 population samples collected from wild sources are maintained by the National Bureau of Plant Genetic Resources (NBPGR), New Delhi and its Regional station at Akola (Maharashtra) (Srivastava,1995). Few lines are maintained at National Botanical Research Institute, Lucknow and at Regional Research Laboratory, Jammu. It occurs widely in northern Kerala, and in forests edges and bushes in Garo hills and east Khasi hills of Meghalaya. A semi-wild type also occurs in west Siang districts of Arunachal Pradesh (Rana *et al.* 1994). High yielding variety having resistance to diseases and pests should be developed.

Chemical constitution

The seed consists of volatile oil present in the seed coat. It is a mixture of farnesol and ambrettolide present to the extent of 0.1222 and 0.03 per cent respectively. The seed also has protein (2.3%), starch (13.35%), crude fibre (31.46%), fatty oil (14.5%) and also moisture (11.14%), and resin (5%). The presence of sitosterol and its glucosides have been reported in seeds (Krishna and Badhwar, 1947; Wealth of India, 1985). The main constituent of oil is sesquiterpene alcohol and farnesol (0.12%). The smell of musk is mainly due to the ketone, ambrettolide, a lactone of ambrettolic acid. Ambrettolide (0.3%) is a colourless viscous liquid.

Aromatic, medicinal and other uses

- The oil extracted from seed (kasturi) is used in producing high qualitiy perfumes, scents and cosmetics as the smell resembles the smell of musk in musk deer.
- It is used in flavouring tobacco and as an ingredient of several medicines.
- The seeds are used as coolant, diuretic, an aphrodisiac, an antispasmodic, a carminative and used as such in native medicines.

- Seed also prevents vomiting and cures diseases occurring due to imbalance of *kapha* and *vata*.
- Decoction of seed is useful in treating nervous debility, hysteria, skin diseases (itching and leucoderma), intestinal disorders, stomatitis and dyspepsia, etc.
- The mucilage prepared from leaves and roots are used in venereal diseases (Mitra and Mishra, 1967; Srivastava, 1976).
- The juice of whole plant is applied on the chest to treat bronchitis (Asolkar, 1992).
- By eating fruit the pets stop regurgitating. Seed pounded with water is given to ailing cow and buffaloes as rejuvenator in Rajasthan (Sebastian and Bhandari, 1984). Pounded seeds when taken, help in retention of semen (Suresh Kumar *et al.* 1980)
- The seed powder is used as cattle or poultry feed.
- The tender leaves and shoots are eaten in soups and green pods as vegetables.
- The stem barks yield fibres which is equally good as jute.

Cultivation technology

Plant grows well under tropical warm and humid climate. Well-drained, loamy fertile soil suits the crop plantation. The pH of soil should be from 6.0 to 8.5. For uniform germination seeds require well pulverized and compact seed beds. The land is dug deeply and fine tilth is brought out. Farmyard manure is applied at a rate of about 50 cartloads/ha. The seeds are sown after pre-monsoon shower in the mid of June till the end of July. Three to four seeds are sown per hill at about 1 cm depth by dibbling. It can also be sown on flat beds in rows 1 × 1 m apart. It has been reported that closer spacing gives higher yield. The rate of seed in case of dibbling is 1-1.5 kg seeds/ha while for broadcasting seed rate is 6 kg seeds/ha. The germination of seed takes place in 6-10 days. If the seeds are treated with carbofuran at 4 or 5 g/100 g of seed weight, they grow vigorously, and flower 2-3 days earlier than the normal and even the seed yield becomes higher. Water logging should be avoided. Irrigation, interculture, weeding and plant protection should be done in normal way.

Plant protection

- Anthracnose is caused by *Colletotrichum hibisci*. This can be controlled by treating the seed with agrosan GN or cerasan before sowing.
- The leaf spot disease caused by *Alternaria hibiscicum* and *Phytophthora* leaf blight caused by *Phytophthora nicotianae* can be checked by treating the seed with cerasan.
- The pest spotted bollworms attack the plant during vegetative growth

and fruting stage (Srivastava,1963). Spraying the plants with thiodon 35 EC (0.15-0.20% solution) at 10–15 days interval from the time they are one month old to the end of the harvest, controls this pest.

- The spraying of 0.05% folidol prevents the web forming red spider mites.

Pruning

The places where the crop shows heavy vegetative growth the pod shows less production. Therefore, the process called pruning is done in which the growing plant is tapped 50–60 cm, leading into pod formation and increase in seed yield. Pruning can be done after 50 days of sowing or transplantation.

Harvesting and processing

The fruits start ripening by the end of November till the end of April, though the fruits should not be picked after the end of February as it yields low. Fruits should be plucked when their three quarter of body turns blackish brown and also before the fruits split and shed the seeds. Since the ripening is not simultaneous so the plucking of mature pods is done once a week. Harvesting of the crop is difficult. After harvesting the pods are dried in shade. The husk from it is removed by thrashing and winnowing. The seeds can be obtained by splitting the dry fruits by hand. The seeds are also dried before storing them.

Extraction of oil

The conventional method for extraction of the aromatic principle is done through hydro-distillation of the whole seed. Srivastava (1986) at National Botanical Research Institute, Lucknow reported the following steps for purifying the 'aromatic principle'

- Extraction of the powdered, air dried seeds by percolation with rectified spirit at ordinary temperature, 4-5 percolations are required for complete extraction.
- Separation of lipid and waxy materials from the alcoholic extract by cooling it at about 0°C and decantation.
- Dilution of alcoholic extract with saturated brine in the ratio of 1: 4.
- Extraction of the diluted alcoholic extract with ether, repeatedly 3-4 times.
- Concentration of the total ethereal extract by distillation.
- Removal of the acidic impurities (free fatty acids) if any, from the ethereal extract by repeated washing (2-3 times) with 1 percent aqueous alkali.
- Removal of alkali by washing it with ice cold water and drying over anhydrous sodium sulphate.
- Distillation of the ethereal extract, firstly in usual manner and finally

under vacuum, to obtain the pure aromatic material.

- Removal of the sterol bodies by filtration after keeping the product in a refrigerator for a few days.

Yield

On an average the normal crop yield 7.5–10 quintals of seeds/ha. (Singh and Gupta, 1961; Srivastava, 1976). With proper manuring and irrigation, the seed yield can be increased to 15-18 q/ha. (Srivastava, 1986). According to Farooqui and Sreeramu, 2001) a normal crop may give a yield of 9–10 q/ha of seeds.

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Dill

(*Anethum graveolens* Linn.)

Dill (Umbelliferae) is also called Garden Dill, Satapuspi, Soya, Sabasige, Satakuppi and urva.

Origin and distribution

There are four species of Dill of which one is indigenous to Africa and three others are indigenous to central and south-east Europe and also central and south-east Asia (Willies, 1966). Indian dill is commercially grown in India and Japan. In India it is mostly grown in Maharashtra, Gujarat, Andhra Pradesh, Madhya Pradesh and Rajasthan for its seeds. Also it is found distributed in Abyssinia, Africa, Egypt, England, Europe, Iran, southern Russia, USA and Sweden (Farooqui and Sreeramu, 2001).

Plant description

It is an annual or biennial aromatic herb with the height of 1 to 1.20 m. The leaves are feathery, standing on a sheathing of foot-stalks, with linear leaflets, compound and light green in colour. The stem is hollow, smooth and shiny,

Dill

grows straight and have flat terminal compound umbels, with numerous yellow flowers. The petals are rolled inwards. The flowers are regular, bisexual, pentamerous. The fruits are dry, flat, groomed and are produced in large number. They are light with very pungent and bitter taste. Fruits have two brown broadly oval, compressed and 2-3 mm broad ridges being inconspicuously brown in colour and the two lateral ridges are yellowish and wing like.

Genetics and breeding

Chromosome number of *Anethum graveolens* is 2n = 22. Out crossing is high, and usually takes place between flowers of the same umbel by swarms and bees. It is observed that selfing reduces the percentage of fruit set (Gupta 1982). Shashilova (1986) observed the greatest variation in the duration of emergence to flowering period from 50–80 days. Development of higher yielding variety resistant to diseases and pests should be bred.

Varieties

- Gribovski.
- Lesnogorodskii: has best flavoured leaves and high oil contents in leaves and seeds.
- Dura with high herb yield.
- K-299 (from Sweden) and K-253 (Georgia) producing high amount of essential oil.
- Mammoth Long Island having highest yield of seed having excellent quality of essential oil.
- Haldwani selection having high seed yield.
- Stamm Weibull having high essential oil content.
- Herkules has high content of essential oil.

Chemical constituents

There are 13 monoterpenoids, 4 phenyl derivatives, 2 methylene dioxyphenyl derivatives, 2 sesquiterpene hydrocarbons and a new dihydrobenzofuran in seed oil. Seed oil is also found to have apoile, carveol, caryophyllence, dihydrocarveol, dihyclrocarvone, dillapiole, D-limonene, D-phelliandrene, eugenol, iso euginol, l-pinene 1-terpinene and myristicin other than carvone.

The principal constituents of seed oil is carvone. Other than phellandrens the oil has pinene, â-pinene, ä-3- careen, terpinent, limonene, y – terpinene, cymene, terpinolene, undecane, cis-3- hexanyl acetate, cis 3 – hexanol, trans – 2 – hexanol, terpineol, carvone, thymol, carvacrol, mysiciticin and apiole. The chemical constituents from roots are coumarins scopoletin, umbelliferone, bergapten and the sterols. Dill roots also produce essential oils which contain carvone and phenyl propane compounds, apiole and myristicin.

Parts used: Seeds, herbs, stem, flowers and essential oil.

Aromatic, medicinal and other uses

- Seed is known to have an essential oil called dill oil. Its emulsion in water is commonly called dill water which is an aromatic, carminative, especially useful in the flatulence, colic pain, vomiting, diarrhoea and hiccups due to indigestion in infants and children.
- The leaves of the plant can be applied as poultice to heal boils.
- Dill with the turmeric powder prevents formation of ulcers and also heals them.
- Leaves boiled in sesame oil makes an excellent ointment for reducing swelling and pain of joints.
- Seeds are effective for treating respiratory problems like cold, bronchitis, influenza (Anon, 1989).
- The essential oil of dill seed completely inhibits the growth of mycelial growth of *Rhizoctonia solani*.
- The stems and blossoms heads are used for dill pickles and for flavouring soups.

Cultivation technology

The sowing should be done in the mid of March, on the well drained soil. Sandy loam type soil is best suited. The pH of soil should be 8.6. Seeds are sown at the depth of 1.5 to 2 cm in a drill or broadcasted. After sowing planking is done. The spacing of 15 × 20 cm for sowing is considered optimum. The germination of seed takes place within a week. There is need to maintain soil moisture. Water logging should be avoided. Irrigation, weeding and interculture should be normally done.

Plant protection

- Aphids occasionally attack the crop and are controlled by spraying malathion (0.5%) 2-3 times during the infestation.
- Powdery mildew (*Erysphie umbelliferum*) is the disease seen in flowers at early seedling stage. It is controlled by spraying wettable sulphur (2%), twice or thrice at an interval of 6 days.
- Root rot disease caused by *Fusarium* sp. is controlled by phytosanitary measures, seed treatment with agrosan at the rate of 3 g/kg of seed and by a foliar spray of Bavistin (0.1%). The plant is also found to be affected by mottling, leaf necrosis, dwarfing and malformation due to viral infections.

Harvesting

The harvesting of dill is done according to the purpose for which it is grown

(Randhava and Kaur,1995). In case of seed yield harvesting is done when the seeds on the tertiary branches turn yellowish brown in colour. Immediately the crop should be taken to the thrashing floor so as to prevent the loss by shattering of seeds. For high production of oil the harvesting should be done at the milky waxy stage of seed maturity (Zlatev, 1977). Maximum herb yield with lowest oil content is produced when the harvesting is done at flower initiation stage. But if harvesting is delayed the herb yield goes down but the oil yield becomes good (Randhawa and Singh, 1991). Seeds with 1/3 to 1/2 of usual moisture, if stored in sealed glass container at 11–20°C for 10–16 years are viable with same yield capacity and quality.

Extraction of oil

The extraction of oil from either herbs or seeds is done by hydro or steam distillation. Partially dried material yields good amount of carvone and less amount of limonene (Chubby and Dorrell, 1976). The extraction done within 72 hours shows the same trend (Balinova - Tsvetkova *et al.* 1976) but according to Zlatev *et al.* (1976) the oil content rises during 48 hours of storage but afterwards the oil content is found to decline to 21.2% of that from the fresh material. During this stage phellandrene increases and carvone decreases.

Yield

The yield of essential oil due to harvesting at various stages are as follows:

Harvesting stages	Oil yield (kg/ha)
Flowering	36.7
Seed formation on primary umbels	69.8
Secondary umbels	102.5
Seed formation on tertiary umbel	113.1
Milk stage	136.5
Maturity	44.5

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Celery

(*Apium graveolens* Linn.)

Celery (Umbelliferae) is also called Karnauli, Shalary, Ajmod, Ajmud, Khurasani Ajwain, Ajmada, Celery Keerai, Ajmoda, Andhpatrika, Randhuni, Chandani, Chanu and Selerin.

Origin and distribution

It originated in Mediterranean area, low lands of Italy, spreading up to France and England. Another hypothesis is that celery was found in marshy places in Sweden from where it extended to south of Algeria, Egypt, Ethiopia, Caucasus and Baluchisthan. The plant is also distributed in Europe, America and Asia. In India its cultivation is for seed. The oil extracted and oleoresin are exported to USA, Europe and Russia. About 90% of the total Indian oil is produced in Punjab. Rest is achieved from Haryana and western Uttar Pradesh.

Celery

Description of plant

It is annual or perennial herb (Farooqui and Sreeramu, 2001). The plant is glabrous, with pinnate compound leaves and long stalk. Flowers are greenish white in colour and present in compound umbels. It consists of 5 petals and 5 stamens. Fruit formed from two compressed carpels, are very small, dark brown cremocarp with agreeable odour and pungent taste which encloses the seeds. Roots are adventitious.

Genetics and breeding

Chromosome number of celery is 2n=22. Most of the species of genus Apium are diploid with 2n=22 chromosomes (Emsweller, 1929). Occurrence of a spontaneous triploid was reported by Whitaker (1941). Celery is not self incompatible and is naturally cross pollinated. Self pollination within the individual flower is restricted due to protandry (Allard, 1960). The variety having high yield and resistance towards pests and diseases should be developed.

Varieties

Apium graveolens var. *rapaceum* is commonly called as celeriac.
Apium. graveolens var. *secalinum*.
Apium graveolens var. *smallage*.
The important high yielding varieties recommended for cultivation under this crop are EC-99249-1 and PRL-85-1.

Chemical components

Two kinds of components, i.e. essential oil (2-3%) and fatty acids (16-20%) are found in the seeds (Randhawa and Kaur, 1995). The herb is also found to have essential oil. From leaves, Choline ascorbate and enzyme Inositol triphosphate are isolated. From roots of var. deluce, 4-phthalides, butylphthalide, neocnidilide, cnidilide, Z-ligustilide and senkyonolide are isolated while from *A. graveolens* var. rapaceum butylphthalide, Z-butylide nephthalide, cnidiliae, E & Z ligustilide, neocnidilide and senkyonolide are isolated (Gijbels *et al.* 1985). The chemical constituents of seed oil are L-pinene, camphene, B-pinene, sabenene, myrcene, 3-carene, L-phellandrene, limonene, B-phellandrene, cis B-ocimene, P-cymene, pentyl benzene, linalool, isoputegone, caryophyllene, carbone, geranyl acetate, L-lonone, cinnamic aldehyde, thymol, B-selinene, epoxycayophyllene, n-butyl phthalide, eudesmol and lingustilide. Of these the limonene is present in high amount (72.1%).

Parts used: Herbs (leaves and stalk), seed, roots and essential oil.

Aromatic, medicinal and other uses

- The seed yields essential oils which are used in food flavouring and

pharmaceutical industries.
- It is also a remedy for rheumatism.
- Seeds are used as stimulant, carminative and also as a nerve tonic in domestic medicine.
- The plant is used in soup and sauces (Bailey, 1963; James, 1953).
- *Apium graveolens* root tubers are cooked and eaten.

Cultivation technology

For sowing the soil should be maintained with pH from 5.0–7.0. The soil except saline, alkaline and water logged ones are suitable. Low humidity, plenty of sun shine, considerable warmth during the day and cool nights are ideal for successful cultivation. Celery is propagated through seeds. The seed should be of high quality or it causes poor stand of plant, with lack of uniformity and vigour. Sowing is done directly in the field, 120 gms of seeds are taken per acre, while in case of transplantation 60 g/acre of seeds are used (Thompson, 1974). The germination of seeds is slow. According to Guzman *et al.* (1973) the seed takes 10–20 days for germination. Singh *et al.* (1985) reported that pre-treatment of seeds with ethylene glycol at 300 g/l for 30 days at 10°C increases the germination by 81%. In nurseries the plants are grown for 60–70 days before transplantation. The sowing of seed in nurseries is done from 15 September to 15 October in plains. On each bed, 50 g of seeds are sown in lines. The seedlings are transplanted 30 cm apart in rows spaced at 30–45 cm. Organic manuring, irrigation, interculture, weeding and plant protection should be attended.

Plant protection

- Leaf miner (*Liriomyze trifolii*) attacks leaves and are controlled by spraying a systematic insecticide like Quinolphos (0.1%). Some other pests are carrot rusfly, celery leaf tier, army worms, fire worms and red spider mites. The control measures for them are practiced at the time they are noticed.
- Late blight is caused by *Septoria petrosalnii*, Early blight caused by *Cercospora apii* and Leaf spot disease caused by *Phyllosticta apii*. The treatment of these diseases is done by spraying thiophanate methyl (0.5%) and manels (0.1%) or fenthin hydroxide (0.2%) at 2 week intervals.
- Some other diseases seen in plant are petiole rot caused by *Sclerotium* spp. and *Fusarium* and also yellow mosaic disease.

Harvesting

After 90–120 days of transplantation the crop is ready to be harvested, though harvesting depends on the purpose for which the crop is grown. The

directly sown crop takes 30–40 days more than that of the transplanted. The harvesting is done by cutting the tap root. For seeds the harvesting is done when the seeds in the umbels turn dark brown from light colour. After harvest the plant should be immediately taken to the thrashing floor to avoid shattering losses. They are then dried and separated from straw by winnowing and grading by sieve. The seeds are then stored in gunny bags in cool and dry places.

Yield

The average yield of celery is about 1000–1500 kg/ha. The celery seeds yield 2–3% of pale yellow volatile oil with a persistent odour.

Extraction of oil

The oil in seed is highly volatile in nature. The volatile or essential oil in the seed is isolated by steam-distillation. The seeds should be crushed and immediately it should be sent for distillation so that loss of oil by evaporation can be prevented. The thing which should be kept in mind while distillation is that the seeds should be spread evenly on perforated grids with which a still serving for seed distillation, should be equipped. It takes 10–12 hours/batch to be distilled. The waste of distillation can be subjected to further distillation.

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Davana

(*Artemisia pallens* Wall. ex DC)

Davana (Asteraceae) is also called Davanam and Davanamu.

Origin and distribution

Davana plant is endemic to India. The plant is mostly distributed in the temperate regions of the world (Anon. 1985). In India it is commercially cultivated in Karnataka. In Maharashtra, Tamil Nadu, Kerala and Andhra Pradesh the cultivation is done to a lesser extent. Attempts to raise this crop have been made in north Indian agroclimatic conditions with limited success (Gulati, 1980). In India, out of 30 sp. of davana most of them are found only in Himalayan belt except some sp. which grow in tropical and sub-tropical plains (Bakshi and Kaul, 1984). India has a possibility of production and export trade of oil of davana. Internationally davana oil is gaining importance in the USA.

Description of plant

It is an erect annual herb of about 60 cm height. Leaves are small and much divided. Flowers are small inconspicuous, yellow in colour (Farooqui and Sreeramu, 2001). The inflorescence is a capitulum which is sessile or may have small peduncle. The capitulum consists of heterogamous flowers, ie bisexual disc florets in the centre and few pistillate ray florets on the periphery. Outer pistillate florets are glabrous except for a few cottony hairs, tubular with generally 2-lobed (rarely 3-lobed) stigma. Inner florets are also like outer florets, but having 5 lobed stigma and being bisexual. It has five stamens with free, epipetalous filaments and dithecous, introse, syngenesious anthers whose connective is prolonged and tapering. The style is bifid (Narayana *et al.* 1978)

Genetics and breeding

The chromosome number of *Artemisia pallens* Wall is 2n = 16. The chromosomal behaviour during diakinesis is found to be abnormal with seven bivalents and two univalents. This could be one of the reasons for low pollen fertility seen in the species (Sunitha and Farooqui, 1990). A study on intra-population variations revealed that the plant height and number of branches are positively correlated with the number of flower heads, weight of flower heads, weight of the herbage and whole plant weight. On the contrary relationship of oil content in flower heads with herbage yield, weight of

capitulum, plant height, number of branches, its spread were more negative and nonsignificant. This work had an objective to select lines which combine high oil content and higher yield through branching with tall habit. Development of variety is to be done so as to produce higher oil yield which should be resistant to diseases and pests.

Variety

There is no systematic attempt made to develop variety for crop improvement. Farmers grow land races which is the result of indirect human and natural selection over a long period of time and maintain their own seeds. In Karnataka and Tamil Nadu five accessions were collected and grown at Bengaluru for their evaluation of yield and its contributing character but it was found that these accessions did not vary significantly among themselves for most of their characters.

Chemical constituents

The oil of Davana is found to have hydrocarbons (20%), esters (65%) and oxygenated compounds (15%) (Lewis, 1967). He suggested that the esters are responsible for the odour of davana. Simpa and Vanderwal (1968) reported the presence of cis- davanone which was also found to be responsible for its characteristic smell. Naegeli et al (1970) reported the presence of sesquiterpene ketone which was named as artemone. Also cinnamic acid was isolated on saponification. Thomas *et al.* (1974) demonstrated presence of novel sesquiterpenoids which was named davanafurans and another ketone named isodavanone.

Parts used: Leaves, flowers and essential oil.

Aromatic, medicinal and other uses

- The oil of davana imparts a sweet, refreshingly pleasant odour on dilution.
- Davana oil is also being used in flavouring cakes, pastries, tobacco products and some costly beverages
- Their essential oil is being used in perfumery, food flavouring and medicines.
- The plant is bitter stimulant antispasmodic and anthelmintic.
- Leaves and flowers of davana emit a delicate, persistent fruity fragrance and are used in floral decorations and also in religious offerings in India.
- The leaves and flowers are artistically blended in floral chaplets worn on the coiffures of south Indian ladies.
- In addition the oil is reported to be anti bacterial and antifungal (Rao and Prasad, 1981).

Cultivation technology

Nursery beds of 2 m length and 1 m width are prepared and well decomposed farmyard manure at the rate of 10 kg/bed is applied. Then 1.5 kg of seeds are mixed with 10 kg of sand and are spread uniformly over the nursery bed and then covered by thin layer of sand. Till the sprouting of seed, water is sprinkled twice a day on the beds. Foliar spray of urea solution (0.2%) is given after seedlings attain 2 inches height at an interval of 3-5 weeks of sowing. After 3-5 weeks the seedling becomes ready to be transplanted. The fields are prepared well for crop plantation, and the land is irrigated a day before transplantation. The spacing at which the transplantation is done is 15 × 7.5 cm. The seedlings are watered immediately after transplanting. Organic manuring, irrigation, interculture, weeding, plant protection etc. are attended.

Plant protection

- Sometimes leaf eating caterpillar, termite, mealy bugs and aphids attack the crop. For controlling them the crop should be sprayed with organic insecticides. However the, spraying of insecticides should be avoided before harvesting.
- *Rhizoctonia* sp. causes the mortality of seedling in damping off diseases. This can be treated by Diathane M 45.

Harvesting

The crop is harvested when 50 per cent of flower buds open during the end of February or first week of March. At this stage maximum oil content of best quality is produced. Harvesting is done by cutting the whole plant at the height of about 6 cm from the ground in bright sunny days. After harvest, the herbage is dried in shade for 24 to 48 hours with 2 or 3 stirrings for 30 percent water loss and is then put to steam distillation for extraction of essential oil.

Distillation of essential oil

The distillation of partially dried herbage is done in galvanized steel or stainless steel unit. Proper atmospheric pressure is maintained. In about 6 hours complete extraction takes place of the partially dried herbage. The oil received should be filtered and made free from sediment, suspended matter and moisture before storing it. To prevent the oil from deterioration the oil is filled in the aluminium container upto the brim so that no space for air is left in the container (Narayana *et al.* 1978)

Tips to get maximum yield of high quality:

(a) Grow the crop satisfactorily by proper time of planting, proper manuring, irrigation, weeding, plant protection etc.

(b) Harvest at proper time and season: Harvest at a time when most of the flowers are opening. Experiments have revealed that if harvested in

March then oil recovery is 0.08 to 0.1 per cent, if harvested in April-May then oil recovery is 0.04 to 0.06 per cent and if harvested in June then oil recovery drops down to 0.01 per cent only.

(c) Expose the crop properly to airy shade: Over 30 per cent loss of moisture is not advisable. Stirrings are a must to avoid fermentation. Otherwise quality goes down.

(d) Fill the herbage tightly in distillation chamber.

Yield

According to Farooqui and Vasundhara (1995) the crop produces average of 15–16 kg of oil/ha on distillation. A well grown crop planted in November yields fresh herbage upto 15 tonnes/ha. It is shade dried by spreading in thin layer. This herbage has 0.2% davana oil. Thus yield of 30 kg oil per hectare can be obtained. Rate of oil is approximately ₹ 8,250 – 10,000/kg.

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Lemon Grass

Cymbopogon flexuosus (nees ex. steud wats)
Syn: *Andropogon nardus* var. Flexuosus Hack)

Lemon grass (Graminae) is also called Indian Malabar or Cochin Lemongrass, Nimbehullu and Kadipullu.

Origin and distribution

It is indigenous to India and large variability occurs in the Western Ghats comprising Kerala, Karnataka and Tamil Nadu besides Sikkim and Arunachal Pradesh. It is now commercially cultivated in Kerala, Tamil Nadu, Asom, Maharashtra and parts of Uttar Pradesh. It is found to grow wild in many tropical and sub tropical parts of Africa, Guatemala, Asia and America.

Description of plant

It is a highly tillered perennial grass. They grow up to the height of 2 m.

Lemon grass

Leaves are lanceolate, often hairy, linear, with distinct ligules. The inflorescence is terminal panicle, highly branched into primary, secondary and tertiary ending ultimately in small paired spikes. Each pair of spike is subtended by a small leafy bract. An inflorescence on an average may have 3,000-4,000 spikes. Each spike consists of 5-11 spikelets in pairs, of which one is pedicillate and other is sessile, attached to a thin zig zag penduncle. The sessile spikelet is awned with four glumes and is a bisexual floret while the pedicillated one is awnless with 3 glumes and is a staminate floret.

Genetics and breeding

The chromosomal number of lemongrass is 2n=20. Presence of a wide range of genetic variability in oil percentage as well as in oil constituents make it possible to select individuals with maximum number of desired characters. Systematic crop improvements programme was initiated at Lemongrass Breeding Station, Odakkali, as early as 1951 through collection of a large gene pool of population samples. As on today, 450 accessions are maintained at the station. From evaluation of several accessions it was found that OD-19 variety is the most popular variety under cultivation. The presence of the characters like good herbage yield, high oil yield content and high citral percentage are its desirable characters. It appears that these characters are polygenic. Variety having high oil yield, better quality, having resistance to diseases and pests should be developed

Varieties

Cymbopogan flexuesus is found to have three types which are (a). *C. flexuosus* var. flexuosus, (b) *C. flexuosus* var. coimbatorensis and (C). *C. flexuosus* var. sikkimensis. The improved varieties of lemongrass are:

- OD-19 (Sugandhi): Released from Aromatic and Medicinal Plants Research Station, Odakkali (Kerala), yields 80-100 kg oil/ha with 85-88% citral under rainfed conditions.
- Pragati (LS 48): Produced by clonal selection from OD 19 at Central Institute of Medicinal and Aromatic Plants, Lucknow. Average oil content is 0.63% with 86% citral (Sharma *et al.* 1987).
- S.D. 68: The oil yield is high with 90% citral.
- RRL 16: It is north Indian lemongrass (*Cymbopogon pendulus*) developed by Regional Research Laboratory, Jammu.
- NLG-84 released in 1994 by AICRP on Medicinal and Arometic Plants by Narendra Deva University of Agriculture and Technology, Faizabad.

Other strains like 'OD-408' from the Aromatic Medicinal Plants Research Station (AMPRS), Odakkali, RRL-39 from Regional Research Laboratory (RRL), Jammu and 'Kaveri' and 'Krishna' from the Central Institute of Medicinal and Aromatic Plants (CIMAP), Regional Station, Bengaluru, have

been released as high yielding varieties for cultivation (Farooqui and Sreeramu, 2001).

Chemical constitution: Mainly citral (70-90%) is present in the oil of lemongrass. Other constituents found are pinenes, camphenes, geraniol, linalool, etc. The oil of OD-19 variety on GLC analysis was reported to have myrcene (0.02%), p-cymere (0.04%), terpinene (0.60%), beta termpineol (0.40%), and terpineol (2.25%), terpinyl acetate (0.90%), borneol (1.90%), geraniol and nerol (1.50%), citral-b (27.70%), citral-a (46.60%) and farnesol (12.80%).

Parts used: Leaves and essential oil.

Aromatic and medicinal uses

- The oil due to its aroma is used for scenting soaps, detergents and an array of other products.
- Citral extracted is an important raw material for perfumery, confectionary and beverages.
- The oil can be used to improve the flavour of some fish preparations and can flavour wines and sauces.
- It is used in the manufacture of Vitamin A.
- Citral rich oil is known for the germicidal, medicinal and flavouring properties.
- It can be used for headaches, toothaches, baths, fermentations, as a diuretic agent, for fever and as insect repellent.

Cultivation technology

Lemongrass being a tropical plant loves hot and humid climate and plenty of sunshine. It cannot tolerate waterlogging. During severe winter its growth is slowed down. In hot summer leaves are damaged. Rainfall 200-300 cm. well distributed throughout the year is ideal for its cultivation. It can grow on the soils from rich loam to poor laterite. Calcareous soils should be avoided.

Lemongrass is mostly propagated vegetatively by rooted slips. They are obtained by splitting clumps dug out from field. About 30-40 slips are obtained from a normal clump. Planting is usually done by onset of monsoon. If irrigation is available then planting can be done in other months also. Once planted, the plantation lasts for 5-6 years. In fertile soil it may grow for 8 years.

The land is ploughed and harrowed. Beds of 1-1.5 m width and convenient length are made with a spacing of 30-50 cm between beds. The beds are made along the contour of the land slopes. In direct seed sowing the seed rate of 20-25 kg/ha is required. Seeds are collected in February- March. Whole inflorescence is cut and dried in sun for 2-3 days and thrashed to get seeds. For uniform distribution of seeds, they should be mixed with sand in the ratio

of 1: 3. In nursery, raising the recommended seed rate is 3-4 kg/ha in April-May. The seeds are uniformly broadcasted on the beds and are covered with a thin layer of soil, followed by sprinkle of water at regular intervals. In about 2 months seedlings are ready for planting.

The seedlings are transplanted in monsoon season (May-June). A spacing of 30 cm × 30 cm with a plant density of 1,11,000/ha is recommended. Under north Indian conditions, wider spacing of 60 cm × 45 cm for seedlings and 90 cm × 60 cm for slips has been suggested. Where there is no rainfall after monsoon then it is to be supplemented by 4-6 irrigations to get optimum yield of herb. Lemongrass usually does not allow weeds to grow under its crown. It is desirable to keep the field clean before application of fertilizer. Usually 3 weedings are required.

Plant protection

- Leaf spot is caused by *Curvularia eragrostidis;* grey blight by *Pestalotiopsis mangiferae*; and leaf spot and clump rot by *Fusarium equiseti* and *F. verticillium;* leaf speck by *Drechslera colocasia* and leaf blight by *Rhizoctonia solani* were reported to infect at Odakkali (Kerala). Prophylactic spraying of Diathane M-45 and Diathane Z-78 @ 3 g/l, thrice on every fortnight reduced the incidence of leaf diseases (Anon., 1981).
- Spindle bug and stem boring caterpillar are controlled by spraying folidol E 605. Though the crop is found to be attacked by many diseases but they did not prove to be very serious.

Harvesting

The crop is perennial in nature and yields well for 5 years (Thomas, 1995). Harvesting is done by cutting the grass 10 cm above the ground level. The harvesting season begins in May and continues till the end of January. First harvest is done in about 90 days after planting. During first year of planting, 3 harvests can be taken while 5-6 cuttings/year can be taken in further years.

Extraction of oil

Oil is extracted through hydro distillation or hydro-steam distillation or steam distillation under field conditions. The lemongrass is distilled for 2-4 hours. Wilting of grass under shade up to 48 hours before distillation increases oil yield (Chinnamma and Menon, 1973). Frequent turning of leaves checks fermentation of leaves. Chopping of wilted leaves to 3 inches size is recommended.

After extraction of essential oil the residual plant material can be called as spent grass. It can be used for composting. After composting it can be an excellent manure. It contains 0.88% nitrogen, 0.01% phosphorus and 1.0%

potash. Guha (1973) reported that the spent grass can also be used as raw material for paper manufacture. Other alternative use may be silage making, material for mushroom cultivation and biogas production (Thomas, 1995). There is a need to modernize the existing field scale distillation for maximizing oil production and to lower fuel consumption.

Yield

The yield of herbage is 15 t/harvest which is responsible for yielding 0.3–0.5% of oil. From second year onwards oil yield of about 350-400 kg/ha is obtained. The oil yield depends on various factors which are as follows: storage of the plant material, treatment of the material and the method of distillation.

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Palmarosa

[*Cymbopogon martinii* (Staph. Van Motia)
Syn: *Andropogon martini* Roxb.]

Palmarosa (Graminae) is also called Rosha grass, Rusa Grass, Dhyamakah, Rohisa, Rusa ghas, Gandha Bel, Palmarosahullu, Kavathampillu, Rauns. Munkilpu, Curaippul and Roshegavat.

Origin and distribution

It originated in subtropical India. It is found distributed in patches in open scrub forests in Madhya Pradesh, Maharashtra and Andhra Pradesh. Also, in a fewer amount it is distributed in Karnataka, Tamil Nadu, Asom and parts of Uttar Pradesh where sporadic collections are made. At present Elichpur, Amravati and Akola in Maharashtra; Khandwa and Betul in Madhya Pradesh and Zeherabad and Mehbubnagar in Andhra Pradesh are trading center of the

Palmarosa

forest based oil of palmrosa. Besides India, it is commercially grown in Indonesia, east African countries, Cuba and Brazil.

Description of plant

It is a tall perennial tufted hedge and attains the height of 1.7 m in forests under favourable conditions. But, under cultivation it attains height of 2.5 m (Farooqui and Sreeramu, 2001). The root are fibrous and shallow. Leaves are long, linear-lanceolate, linguate, glabrous beneath, partly sheathing the stem with cordate to sub-cordate base. Flowers are large, inflorescence visible in the month of September to November containing white, hairy star like spiked flowers.

Genetics and breeding

The chromosomal number of plant is 2n=40. Palmarosa is highly heterogenous species where hermaphrodite flowers constitute only 25–35% of the florets in an inflorescence and the rest are staminate. Pollen fertility varies from 84 to 96% in staminate and hermaphrodite florets. The florets are small, delicate with feathery stigma and make production of seed set from inbred and hybrid lines difficult.

Varieties

- IW-31243 and IW-31245 were found to be superior selections. Out of the two IW-31245 gave marginally higher yield and superior rosaceous odour characteristic of palmarosa oil (Pareek *et al.* 1981 and 1985 and Pareek and Maheshwari, 1990) and was released for cultivation from National Bureau of Plant Genetic Resources (NBPGR), Delhi.
- RH-49 was identified as high yielding variety by Punia *et al.* (1988) at Hisar and was released from Choudhary Charan Singh Haryana Agricultural University, Hisar.
- Trishna was developed by Sharma *et al.* (1987). It gave 40% higher oil yield over commercial check. (iv) Tripta a high yielding variety was released by CIMAP, Lucknow.
- PRC-1 is another important high yielding variety recommended for cultivation.
- CI-80-68 released by AICRP on Medicinal and Aromatic Plants, Indore.

Chemical constituents

Geraniol (70-80%) is the major constituent of *Cymbopogon martini* (Gupta and Pareek,1995). Other constituents are Pinene, Myrcene, Limonene, 1,8-Cineole, â-terpinene, n-flexanol, Prenyl-isovalerate, Amyl hexanoate, Linalool, Prenyl hexanoate, â-caryophyllene, Neryl formate, Geranyl formate, Gerenial,

Geranyl acetate, Nerol, Prenyl Octanoate, Geranyl butyrate, Geranyl isovalerate, 6,7-Geranyl exposide, 2,3-Geranyl expoxide, Caryophyllene expoxide, Geranyl hexanoate, ñ-Mentha-1 and 8 (10)-dien –9-ol. Geraniol is found in both either free or combined form. Some minor constituent reported are citronellal, citral, dipentene, etc.

Parts used: Flowering tops, foliage, stem and essential oil.

Aromatic uses

- The oil is used in perfumery, cosmetics industry, soaps and in blending of tobacco products.
- Plant serves as a source of very high grade geraniol. Geraniol is highly valued as a perfume and as a starting material for a large number of synthetic aroma chemicals, viz. geranyl esters, which have a permanent rose like odour.

Cultivation technology

A well-drained loamy soil with a pH of 6–7 with irrigation facilities is ideal for the cultivation of palmarosa. It also grows well in well-drained clayey loam soils, free from water logging. The plant grows well in a warm tropical climate with an elevation of upto 300 m. The plant thrives well under the temperature between 10–36°C and annual rainfall of about 150 cm with ample sunlight. The land is ploughed and harrowed to a fine tilth and during last ploughing FYM is added to the soil @ 10 t/ha. It can be propagated by (1) transplanting the nursery raised seedlings (2) by root-cuttings of healthy plants and (3) by slips as described below:

Nursery raising: Nursery beds are prepared in May. Liberal amount of FYM should be added to the seed beds. Seeds are small and light so are mixed with fine soil in the ratio of 1: 10 so that there occurs even distribution of seeds and also it leads to easy sowing. The seeds are sown in lines at 15-20 cm apart. The overcrowding of seed during sowing should be avoided. About 2.5 kg of seeds are considered adequate for raising seedlings for planting 1 ha. The beds are watered lightly and regularly. Germination of seed takes place in two weeks after sowing. For good growth a weak solution of urea (0.2-0.5%) may be sprayed. In about 3-4 weeks, the seedlings are ready for transplantation. The transplantation is done in rainy season (June-July).

- ***By root-cuttings:*** The root cuttings are collected from the plants which give a good yield and high quality oil. By root cutting it is possible to raise plants with good yield of oil which is not possible with that of seed propagation. However, the rate of establishment of rooted slips is very poor as compared to nursery transplants.

- ***By slips:*** It can be planted by root slips in June-July during the rainy season. Manuring, irrigation, interculture, weeding plant protection are attended.

Plant protection

Leaf spot disease is caused by *Colletotrichum caudatum* var Sarvakar (Sarvar and Parmeshwaran,1981). Leaf blight disease is caused by *Curvularia andropogonis*. Findings on control measures of both the diseases by appropriate fungicides have been reported.

Harvesting

The whole plant has essential oil, i.e. the flower heads, leaves and stems, though flower top having the major portion. The harvesting is done on the full bloom of the plant, i.e. after 4 months of transplantation. During harvesting whole plant is cut at a height of 6 cm from the ground level. The maximum yield of oil is obtained when the entire plant is cut at full flowering stage. The climate conditions decide the number of harvests. In first year, the first harvest is obtained during October-November, whereas 2-3 harvests can be obtained from subsequent years. Palmarosa plantation remains productive upto 8 years. However, the yield of grass and oil starts decreasing from the fourth year onwards. Therefore, it is recommended that plantation should be kept only for 4 years.

Extraction of essential oil

Generally, palmarosa is subjected to hydro-distillation, since a long time. But, steam-distillation method is better because the quality of oil is better than that of hydro-distillation. The equipment of distillation have boiler to produce steam, a still, a condenser and separator.

The still is made of mild steel and has perforated bottom on which the grass rests. The still has a steam inlet pipe at the bottom. A removable lid is fitted at the top. Charging and discharging can be done in perforated cages with iron chains which can be lowered into the still with the help of a chain-pulley block. Different types of condensers are present in the market, but tubular condensers are better than the others. To cool the pipes of distillate there is present a condenser having an inlet and outlet through which the cool water flows.

The grass should be chopped into shorter lengths so as to facilitate the release of oil and also more grass can be charged into the still. The grass should be packed firmly as this prevents formation of steam channels. Steam is allowed to pass into the still with a pressure from 18-32 kg/sq inch in the boiler. The mixture of vapours of water and palmarosa oil pass into the condenser. On distillation, the distillate condenses in the condenser. The oil is lighter than the water and is insoluble, therefore floats on the top of the separator and is continuously drawn off. The oil is then decanted and filtered.

Yield

Herbage yield, essential oil yield and odour as per the stages of harvest (Pareek *et al.* 1981) are tabulated below:

Stages of harvest	Herbage q/ha	Essential oil % FWB	Essential oil yield (kg/ha)	Odour
Most flower open	314	0.493	157	Terpenic Rosaceous
Early seed formation	272	0.499	136	Rosaceous
Late seed formation	240	0.440	105	Rosaceous

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French jasmine

(*Jasminum grandiflorum* Linn)

French jasmine (Oleaceae) is also called Arabian Jasmine, Royal Jasmine, Catalonian, Jati, Magadhi, Chameli, Jajimalige, Jaji, Jati and Pitchi.

Origin and distribution

It originated in Indo Burma region in the foothills of Himalayas (Farooqui and Sreeramu, 2001). This crop is distributed in Morocco, Egypt, south Africa, Syria, Tunisia, Algeria, United Arab Republic, Sicily, India and China on plantation scale.

In India it is grown in Tamilnadu (Mettupalayam, Coimbatore, North Arcot, Chengalpet, Kanyakumari, Tirunalveli, Madurai, Hosur, Rajapalayam, Chennai etc). Also it is found distributed in Karnataka (Mysore), Andhra Pradesh (Penukonda) and Maharashtra (Aurangabad).

French Jasmine

Plant description

It is a climber but may be trained as bush. Leaves are apposite, compound with 6-9 leaflets. Flowers are hermaphrodite, possessing 5-7 petals and 5 sepals, persistant, and two bilobed anthers. The gynoecium has one ovule, simple style and bilobed stigma. Ovary is superior with exile placentation. Fruit is one seeded. Naturally, 0–3 seeds are produced per plant.

Genetics and breeding

Diploid (2n=26) and triploid (2n=39) cytotypes have been reported by Dutta (1960) and Karmakar and Srivastava (1988). The triploid strain Pink Thrum has been identified as autotriploid (Srivastava and Karmakar, 1986). Reduction in frequency of trivalents and high frequency of univalents were attributed to the small size of chromosomes. The triploid strain produce a few viable seeds which may be utilized to grow aneuploid

Clonal selection of the germplasm Lucknow at Tamil Nadu Agricultural University, Coimbatore resulted in a variety CO-1 pitchi having 0.29% concrete. It was one of the six clones evaluated for various economic characters (Veluswamy, 1980). Clonal selection (Bhupal Rao *et al.* 1977; Srivastava and Karmarkar,1986) at the Indian Institute of Horticultural Research, Bengaluru resulted in an improved variety Arka Surabhi (Srivastava *et al.* 1997). It has pin type flowers having 0.35% concrete. Studies of very large population of *Jasminum grandiflorum* plants have resulted in seed producing spontaneous variant (Srivastava and Karmakar, 1988). Also a dwarf plant type has been identified (Srivastava and Karmakar,1988). Its flower yield is less.

At Indian Institute of Horticultural Research, Bengaluru *Jasminum grandiflorum* germplasm includes cultures Lucknow, Thimmapuram, Coimbatore, Bengaluru, Co-1 Pitchi, Triploid, Pink Thrum, White Pin, White Thrum, Dwarf, Seed Producing Clone, Super high concrete, Foliar Beauty, etc. Over 120 accessions are maintained at this research institute of ICAR in Bengaluru. Hybridization between Arka Surabhi and Seed Producing Clone has been successfully done in IIHR, Bengaluru.

New varieties of other aromatic jasmines: Since few years other two aromatic jasmines, ie *Jasminum sambac* Ait and *Jasmnum auriculatum* Vahl have gained importance in aromatic industry. Because not even a single variety for essential oil production could be available therefore, the Indian Institute of Horticultural Research, Bengaluru took up research on development of aromatic varieties in these species. After several years of studies in case of *Jasminum sambac* the varieties Arka Aradhana and Iruvatchi have been identified as superior varieties for essential oil production. Arka Aradhana yields 7.98 tonnes flowers/year/ha with 0.188% concrete resulting 15.25 kg concrete/hectare (Srivastava and Vasantha Kumar, 2003). The variety Iruvatchi can yield 8.35 tonnes flowers/year/ha with 0. 263% concrete leading to yield

of 21.9 kg concrete/hectare (Srivastava and Vasantha Kumar, 2003). In case *Jasminum auriculatum* a better variety IIHR-JA-13 has been developed. IIHR-JA-13 yields 6.9 tonnes flowers/year/hectare having 0.454% concrete resulting 31. 243 kg concrete/hectare (Srivastava and Vasanth Kumar, 2004).

Varieties

- **Co 1 Pitchi:** developed by Tamil Nadu Agricultural University, Coimbatore. Yield about 10 tonnes flowers/year containing about 0.29% concrete. Potential yield of concrete 29 kg per hectare. Potential yield of absolute 14. 5 kg per hectare.
- **Arka Surabhi:** It contains about 0.35% of concrete and the yield of flower is about 10 tonnes. It has been released by the Indian Institute of Horticultural Research, Bengaluru (Srivastava *et al.* 1997). Potential yield of concrete is 35 kg per hectare. Potential yield of absolute is 17. 5 kg per hectare.
- A promising line IIHR –JG-27 having very high content of concrete ie 0.9% has been developed by the Indian Institute of Horticultural Research, Bengaluru. But its flower yield is very less (Srivastava and Vasant Kumar, 2004).

Chemical constituents

Buil *et al.* (1981) examined *Jasminum grandiflorum* absolute produced from hexane extraction and reported these components: Methyl Jasmonate, Jasmone Neriolidol, Cis – 3 – Hexenyl Benzoate, Benzyl Benzoate, Methyl Jasmonate, Methyl Palmitate, Farnesol, Methyl N-acetyl Antharanilate, Ethyl Palmitate, Methyl Stearate, Geranyl Linalool, Methyl Oleate, Methyl Linolenate, Ethyl Stearate, Phytol Methyl Rinoleate, Phytol Ethyl Bleate, Ethyl Linolenate, Phytyl Acetate and Methyl Linoleate. Srivastava *et al.* 1997 have reported following chemical composition in absolutes of varieties Arka Surabhi and CO-1 Pitchi.

Constituents	Arka Surabhi	CO-1 Pitchi
Linalool	5.02	2.97
Benzyl Acetate	13.62	8.48
Benzyl Alchohol	1.87	0.89
Cis Jasmone	8.97	7.22
Methyl Anthranilate	1.43	Trace
Iso Phytol	9.33	8.54
Indol	3.67	3.83
Phytol	4.53	6.69
Benzyl Benzoate	10.19	10.57

Parts used: Flowers and essential oil.

Aromatic and medicinal uses

- Concrete and absolute obtained from jasmine flowers have tremendous export value. This finds a very important place in essential oil industry. All high grade perfumes have blend of French Jasmine essential oil.
- Its essential oil is used in aroma therapy.
- Jasmine tea is used for its calming affect, especially after dinner, as well as for its aphrodisiacal qualities.
- Jasmine oil soothes the skin and reduces menstrual cramps.
- The oil, when used in aromatherapy, can treat depression and nerve conditions.
- Jasmine is also used to treat headaches, spasms, and neuralgias (encephalitis) associated with the flu.
- *Jasminum grandiflorum* has been used as herbal remedies - an alternative to standard allopathic medicine for a variety of problems, including cancer (especially of the bone, lymph nodes and breasts), stress relief, anxiety as well as for easing depression.

Cultivation technology

The crop grows well on well drained loamy soil though it can grow on variety of soils like black laterite, clayey loam and gravelly-loam. Mild climate with sufficient sunlight and rainfall of 80–100 cm is good for the crop. Plantation is done at the spacing of 2 m×1.8 m for optimum yield (Bhattacharjee, 1985).

The plant can be propagated by either shoot tip cuttings or semi – hardwood cuttings. The shoot tip cutting has been found to be a better method for propagation. The shoot tips are treated with IBA 4000 ppm. Such treated cuttings produced maximum number of well developed roots (Bhattacharjee *et al.* 1979). The rooting can be also brought about in Closed Media Sachet (CMS) technique of propagation which does not need watering for almost two months. It also deletes need of electrically operated intermittant mist chamber. Details of this technique are published by Srivastava, 1989 and 1998. Propagation cost of saplings is reduced to just fifty paise/sapling.

Farm Yard Manure 10 kg along with 50 gm N, 150 gm P_2O_5 and 100 gm K_2O need to be applied to each plant for realizing higher yield of essential oil. Three splits in nitrogen should be applied during April, August and November. It has increased flower yield by 30 percent. Pruning in middle of December at 90 cm height and 13^{th} node has been recommended.

Bhattacharjee working in the Indian Institute of Horticultural Research, Bengaluru during 1980s has reported that spray of Cycocel (CCC) at 1000 ppm and B-nine at 5000 ppm during early vegetative period induces early flowering, enhance flowering duration with more number of flowers containing high essential oil content. Indole Acetic Acid and Gibberelic Acid at 10 ppm

also improved flower yield by increasing flower size and number of branches respectively. Chemicals like Paraquot Dichloride (3000 ppm), Potassium Iodide (3000–4000 ppm) and Pentachrophenol (2000 ppm) can also be employed as defoliants wherever labour is costly.

Jasminum grandiflorum var. Arka Surabhi has expressed remarkable tolerance to drought conditions. In an experiment at Hessarghatta, Bengaluru nil irrigation for over three years to established plants did not cause any wilting or casualty. All the plants remained healthy. Of course, the yield got reduced to almost 50%. However, for optimum yield of flowers and essential oil, irrigation is required at about 12 days interval during summer and about 20 days in rainless season (Srivastava, 1990). By interculture and weeding the field should be kept clean especially before application of fertilizer.

Plant protection

- Rust disease caused by the fungus *Uromyces hobsoni* and leafy spot disease caused by *Cercopora jasminicola* are controlled by spraying Bordeoux Mixture at an interval of one month from May to December.
- Termite (*Odototermes obesus* and *O. wak2kibebsus*) attack is prevented by treating soil with Aldrex.
- Stem Borer (*Sycophylla* sp.) is controlled by spraying of Nuvacron (0.2%) from June to December.
- Bud worm (*Hendecasis duplifaciallis*) is checked by Carbofuran (40 g/plant).

Effect of plant age on chemistry of absolute: Absolute obtained from 2 years, 6 years, and 12 years age. *Jasminum grandiflorum* var. CO-1 Pitchi plants were analyzed for ten important constituents. The results revealed that aging of plants reduces content of linalool, benzyl acetate and benzyl alcohol. On the other hand, content of indol, eugenol, phytol and benzyl benzoate expressed increasing trend with ageing of plants. Isophytol content increased upto 6 years but decreased afterwards. Twelve years age of plant expressed slight depression in concrete content (Venkateshwarlu and Srivastava, 1998)

Harvesting of flowers

The plant flowers in the first year itself, but the flowering increases with its age. Commercially the yield of flower commences from third year and last upto the age of 12–15 years depending upon management. Harvesting is done by picking the flowers between 3–7.5 am. Harvesting afterwards lowers the quality of concrete. From 3 to 7.5 am each plucker harvest nearly 3 kg flowers/ day. Instead of opened flowers fully matured buds may also be harvested in day time. Fully matured picked buds are spread in one layer in a closed chamber. Open floral buds may be processed for extraction of essential oil. But labourers may also pluck immature buds which will not flower, so it will be a waste.

The flowers are processed by solvent extraction technology for extraction of essential oil. In north India, the harvesting is done from July to November while in south India it is done from May to December.

Yield and price of concrete and absolute

Under the condition of Karnataka and Tamil Nadu the yield of flower in first year is half a tonne, second year it increases to about 5 tonnes/ha while in third year it reaches to 10 tonnes/ha. Good yield lasts till 12–13 years if the plant is managed well. Concrete yield is 29 to 35 kg/ha and absolute yield is 14.5 to 17.5 kg/ha depending on variety. Price is about ₹ 17,000 per kg concrete and ₹ 35,000 per kg of absolute in international market.

Extraction of essential oil

The essential oil can be extracted in 3 ways.

Solvent Extraction: It is most common method. The fresh flowers are immersed in organic solvents (food grade hexane). The solvents dissolve essential oil along with waxes. The waste petals are removed and the distillation of miscella is done at low temperature. Vapour of the solvent is condensed for reuse. The remaining material of concentrated miscella is dried at low temperature. The material obtained is waxy, brownish and is full of jasmine smell, known as concrete. The concrete is a saleable product. Concrete is treated with absolute alcohol and filtered at very cold temperature due to which wax separates. The end product is semi-viscous, dark-coloured material, full of fragrance of fresh jasmine, called absolute or 'otto'. It is marketed at high price in international market.

Enfleurage: The essential oil of flower is absorbed by fat. After the fat (dehusked sesame seed, etc) get saturated, the fat is then separated from essential oil. The flowers are replaced on the fat by fresh flowers daily for about one week. After the fat get saturated essential oil is extracted. It is ld method.

Dynamic Absorption Method: The vapour of jasmine is passed on activated charcoal and deabsorption of oil from absorber by volatile solvent. The yield of essential oil has been found to be better.

Marketing

Due to high cost of jasmine essential oil and availability of cheap synthetic substitute the domestic consumption of natural jasmine essential oil is very less in India. It is exported to France, Italy, Russia, Japan, Germany and USA etc. The price depends on demand and supply and quality of the concrete. It varies from ₹ 14,000 to ₹ 20,000/kg of concrete. Absolute sells at almost double price. Marketing is done by individual manufactureres. Organized marketing should be arranged by government.

Economic viability

Seeing the excellent price of jasmine concrete and absolute in international market there is excellent economic viability for jasmine cultivation for extraction of essential oil. In this regard a study conducted at the Indian Institute of Horticultural Research, Bengaluru has been summarized by Srivastava (1999) during a Conference at the Central Institute of Medicinal and Aromatic Plants, Lucknow. There is very good export demand for flowers of *Jasminum sambac* and *Jasminum auriculatum* in the Gulf and other countries.

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Chammomile

(*Matricaria chamomillae* Linn.)

Chammomile (Compositae) is also called German Chamomile, Chammomile, Small Chamomile, Persian chamomile, Babuna, Babuni-ka-phool, Seema and Suteigul Seventhi Poo.

Origin and distribution

It originated from Europe and cultivated in Germany, Yugoslavia, France, Hungary, Russia and India. In India it is found to be cultivated from about three hundred years. The plant was introduced in Punjab about three hundred years ago. During Mughal period it was introduced in Jammu in 1757. It is now commercially grown around Lucknow (Uttar Pradesh), Delhi, Mumbai, Jammu, Madhya Pradesh and Punjab.

Chamomila

Plant description

It is a small herbaceous erect annual plant. Height is 60 – 90 cm. Leaves are pinnatifid and segments are very narrow and linear. Flowers are protandrous. The male and female parts mature at different times having a time lag of 24–28 hours. So it is specifically cross pollinated. Head is solitary. Each flower head is borne on a hemispherical or conical hollow receptacles surrounded by involucre of 2-3 rows of small imbricate bracts. The ray florets are 10 –20 in number, whitish or yellowish. Disc florets are numerous, yellow, tubular with long peduncles of dark brown or dusty greenish yellow in colour. Fruit is an achene with 3-5 faint ribs (Chandra *et al.* 1979). A single head produces 40-50 seeds. Seeds are generally rounded, small and pointed at end. They are yellow or light brown in colour.

Varieties

- Sorakar - 60: It is from Hungary, grows well with good oil. The seeds being small are mixed with sand or fine soil in the ratio of 1: 4 before sowing in the nursery beds. Watering should be done regularly.
- Vallary: This high yielding variety has been released by the Central Institute of Medicinal and Aromatic Plants, Lucknow.

Chemical constituents

The oil is found to have (a) chamazulene (1–15%) which gives blue colour to the oil (b) azulene is in the free form, formed during distillation. The essential oil produced is known as Blue Oil due to its deep blue colour. The essential oil extracted from the flowers is to have azulene (1-15%) which determines the quality of oil. Other constituents are pro-chamazulene, matricin, terpene hydrocarbons, sesquiterpene alcohols including bisabilol, and unsaturated ketonic alcohol bisabalol oxide, methoxy coumarone, furfural and paraffins. The active constituents of the flower are viscous oil, a bitter principle apigenin and its glycoside apiin, quercimetritrin, 7-methoxy coumarin, 7- hydroxy coumarin, adioxy coumarin, areesin phytosterol, fatty acids, vitamin C and nicotinic acid.

Parts used: Flower, seed and essential oil.

Aromatic and medicinal uses

- The essential oil is also used as flavouring agent in fine liquors.
- The oil is used to flavour pomades and pain relieving balms.
- Both flower and oil are used in flavoring shampoo, facecreams, ice creams, ice candy, baked foods and chewing gums.
- Flower has essential oil and the oil is antiphlogistic and is used as a remedy in gastrointestinal troubles.
- Dried flower is used as a component of herbal tea for promoting the

flow of gastric secretions and bile.
- It is also used in the treatment of cough and cold.
- In Europe it is used as a mild sedative.
- The oil being therapeutic acts as an antispasmodic, expectorant, carminative, anthelmintic, anti-inflammatory and diuretic.
- The oil is used in infant's ailments such as teething trouble and stomach disorders.
- It has been used to regulate monthly periods.
- It is splendid for kidneys, spleen, colds, bronchitis, bladder troubles, to expel worms, for argue, dropsy, and jaundice.
- The tea is believed to make an excellent wash for sore and weak eyes and also for other open sores and wounds.
- Chamomile has been used as a poultice for pains and swellings.
- It has been used for hysteria and nervous diseases, prevention of gangrene, for breaking up typhoid and in combination with bittersweet for bruises, sprains, calluses and corns.
- The oil has antibacterial and fungicidal activity.

Cultivation technology

Chamomile can grow on variety of soil. Moderately heavy soils rich in humus are best suited soil. The optimum pH of soil should be 7. In plains the crop is grown in winter. Summer crop is grown on the hills upto an altitude of 2000 m. The optimum temperature for seed germination is between 10–20°C. The chamomile can be propagated by direct seed sowing as well as by nursery raising as described below.

Direct seed sowing

In direct seed sowing around 3 kg of seeds are needed to raise 1 ha of plantation. Thousand seeds weigh from 0.088 to 0.153 g. Seeds are mixed with fine sand before sowing.

Nursery raising

The seeds are sown in nursery beds at the rate of 1 kg for plantation of 1 ha. The seeds are sown in nurseries during late September or early October and the seedlings are transplanted by the last week of November or by early December. Before transplantation the field should be prepared by moldboard plough, harrow and cultivator. Also well-rotted farmyard manure is applied to the seeds to germinate in 15-20 days of sowing and in 5-6 weeks they become ready to be transplanted. The transplantation is done at the spacing of 30 cm × 30 cm. This spacing gives maximum flower and the yield of essential oil is also high. But for varieties with a spreading habit, spacing of 40 × 40 cm is recommended. Organic manuring, irrigation, interculture, weeding, plant

protection, etc. should be attended.

Plant protection

The plant has not been found being seriously affected by any pests or diseases. However, black bean aphids (*Aphis febae*) and an insect *Nysious minor* attacks flowers and causes their shedding. Black bean aphid is controlled by spraying Phosdrin at 0.1% concentration and Brevinyl at 0.5% concentration. *Nysious minor* is controlled by spraying of Endosulphan (0.2%). Also a defoliating insect *Andographis chryson* has been found affecting the crop.

Harvesting of flowers

Harvesting is done as soon as the pod matures fully. The delay may result in shedding of seeds. The harvest is either done by hand picking or by means of flower scoops or skipper. About 4-5 harvests could be done at an interval of every 10-15 days. The maximum flowering is seen during 3rd or 4th harvest. The last flush of flowers (5th) will be allowed to set seeds on the plant itself.

Yield of flowers and seeds

Temperature, light and soil have a significant effect on essential oil and azulene content. On normal soil an average yield of flower is 6000 kg/ha. On dry basis it is 1000 to 1500 kg/ha. While in saline alkaline soils the yields will be 4000-5000 kg/ha. The seed yield will be around 150-200 kg/ha.

Extraction of essential oil

The oil is extracted from the flowers (air-dried) by steam distillation. Steam of 7 atm/sq cm pressure is used from the steam generator. The oil gets deposited on the inner walls of the condenser, then comes out. The whole process of extraction takes about 5 hours. The yield of oil varies from 0.3 to 1.3% depending upon the location, strain and the conditions and the fertility status of the soil. Temperature, and light have significant effect in essential oil and azulene content.

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Japanese Mint

(*Mentha arvensis* Linn.)

Japanese mint (Labiateae) is also called Putiha papant, Japani Pudina, Japani Mint, Japanese Mint and Putina.

Origin and distribution

It is native of Japan. It is found distributed in USA, south-east Asia and Latin American countries. Japanese mint is commonly grown in India., China, Thailand, Taiwan, Brazil, USA, Japan, Paraguay, Argentina, Vietnam, France, South Africa, Italy, Yugoslavia, Hungary, UK and Bulgaria. In India it is cultivated in Uttar Pradesh and Uttarakhand particularly in Tarai districts, eg. Nainital, Badaun, Rampur, Moradabad, Barabanki and Lucknow. It is also cultivated in parts of Punjab (mainly in Ludhiana and Jalandhar). In addition

Japanese Mint

to these it is also being cultivated in some parts of Madhya Pradesh, Bihar, and Jammu and Kashmir.

Plant description

It is a perennial herb. It has rigid, pubescent branches and 60–90 cm tall. Leaves are lanceolate to oblong 3.7–10 cm long sharply toothed or shortly petioled and hairy. Flower are arranged in cyme which are usually sessile and rarely pedunculate. The flowers are purplish and minute. Calyx is deltoid and acuminate. Corolla is white to purple. Roots are just under the surface.

Genetics and breeding

Sharma and Bhattacharya (1959) have studied cytology of *Mentha arvensis* growing in Himalayas and reported its 2n = 90. European genotypes have 2n = 72. Chinese variants are reported to have 2n = 96. Breeding work is being done by Central Institute of Medicinal and Aromatic Plants, Lucknow for high yield of essential oil, high content of menthol and resistance to diseases and pests. An ideal plant type should have erect branching nature, producing vigorous bushy growth with high leaf stem ratio. The largest germplasm collection is maintained by USDA Agricultural Research Service in USA.

Varieties

The Japanese mint has three horticultural types one with reddish purple stems and broad obtuse leaves and the other two have green stems, broad or narrow leaves with purplish-green stems and narrow leaves respectively.

Following are the popular varieties:

(i) Himalaya: Selection from Thai bud sprout released by Central Institute of Medicinal and Aromatic Plants, Lucknow, Uttar Pradesh.

(ii) MAS-1: Yield of oil is around 290 – 293 kg/ha.(CIMAP, 1983).

(iii) Hybrid- 77: Evolved by crossing MAS-1 × MAS-2. It produces 762 q/ha of fresh herb, 468 kg/ha essential oil containing 81.5% menthol (from 3 cuts). It is resistant to leaf-spot and rust diseases. It has been released by Central Institute of Medicinal and Aromatic Plants, Lucknow. (CIMAP Newsletter, 1985, 12 (3): 1-2.

(iv) EC-41911: It is interspecific cross between *M. arvensis* × *M. piperita.* It produces 236.5 q/ha of herbage and 125.2 kg/ha of oil with 70% menthol.

(v) Shivalik: It is a clonal selection from China. It is a high yielding variety released by CIMAP, Lucknow.

Chemical constituents

Mentha arvensis oil consists of menthol (74.84%), 1 – menthone (10.21%), isomenthone (4.15%), neo-menthol and menthyl acetate (5.84%) and

hydrocarbons (4.93%). The hydrocarbons include 1-pinene, 1-limonene, caryophyllene, cadinene and some unidentified sesquiterpenes. In mint oil, methyl acetate and terpenes are also found to be present.

Aromatic and medicinal uses

It is the principal source of menthol in the world. It is used in treatment of cold. It is also used in cough, mouth wash, cosmetics, scenting cigarettes and flavouring cough drops. The peppermint oil is an excellent carminative, anti septic preservative and gastro-stimulant. Its pleasing odour can influence behaviour and induce alertness in patients. The oil of spearmint is rich in carvone, a digestive and gastrostimulant compound. The oil of bergamot mint is rich in linalyt ocelate and linalool and is used in cosmetic industries.

Cultivation technology

Japanese mint is grown in winters in plains while it is planted in autumn or spring in temperate climates. The soil ideal for the growth of crop is medium to fertile deep soil which should be rich in humus. The soil though should have good water holding capacity but water logging condition should be avoided. The pH of soil should be 6–7.5. A temperature of 20 – 25°C promotes vegetative growth, but the essential oil and menthol are reported to increase at a higher temperature of 30°C under Indian conditions.

Mints propagate via creeping stolons or suckers. Stolons may be obtained from the previous year planting. About 400 kg stolons are required for planting one hectare of land. The best time for attaining stolons is during the month of December and January. A hectare of well established mint, on an average provided enough planting material for about 25 hectares. The stolons are cut into small pieces of 7–10 cm and are planted in shallow furrows about 7–10 cm deep with a distance of 45 × 60 cm manually or mechanically. After planting, irrigation is done. Interculture, weeding, plant protection are attended. Gulati and Duhan (1971) reported that by use of 90 kg of nitrogen/ha with high P and K fertilizers, yield of 430.6 quintals/ha of fresh herb and 182.5 kg/ha of mentha oil were obtained. Gupta (1995) reported that following crop rotations are common in Uttar Pradesh.

(a) Maize – Mint–Potato
(b) Mint - Early Paddy - Potato
(c) Mint - Late Paddy - Sweet Pea

Plant protection

Insects: It is attacked by as many as 54 insect- pests and mites in India, and of these 40 are recorded in Punjab. The major six of them are:

- Termites (*Odontotermes obosus*) leads to the wilting and finally death of the plant (Gupta and Agarwal, 1963). Also the use of 3% Haftaf –

heptachlor dust @ 45 – 55 kg/ha against termites is recommended.

- Red pumpkin beetle (*Aulucophora fovicollis*) affects leaves and buds. The pest is checked by spraying of aldrin 0.02% during early hours of day-break. Also spraying of malathion 0.1% is found to be effective.
- Mentha leaf-roller (larvae of *Syngamia abruptalis*) sticks on the under side of the leaf. They are controlled by spraying of aldrin 20 EC or thiodan at 1 l in 700 l of water.
- Bihar caterpillar (*Diacrisa obliqua* Walter): Sagar (1989) has reported outbreak of *Diacrisa obliqua* on Japanese mint in Punjab.
- Semi-loopers feeds on tender crown leaves. Spraying of endosulfan (thiodan 25 EC) in 700 l of water per hectare is effective.
- Cut worms (*Agrotis flammatra*) affects the young plants. Treatment of soil with 25 kg of aldrin before plantation may control the pest.

Diseases

- Stolon rot is caused by *Macrophomina phaseoli* (Hussain and Janardhan, 1965). It can be controlled by treating the disease free stolons with 0.2% solution of captan. Also, the infected plant along with soil is picked and is burnt to check its spread.
- Leaf blight caused by *Alternaria* sp. Spraying of any copper fungicide checks the infection (Ganguly and Pandotra, 1962).
- Wilting caused by *Verticillium alboatrum* (soil borne pathogen) spreads via root. The disease is controlled by treatment of soil with methyl isocyanate. This operation is considered to be quite expensive (Guenther, 1961)
- Rust caused by *Puccinia menthae* can be controlled by spraying of dinitroamine at 2 kg a.i. per ha in 800 litre of water before sprouting of plants in field.
- Powdery mildew caused by *Erysiphae cichoracearum* can be controlled by spraying wettable sulphur at 0.5% containing 50% elemental sulphur. The spaying should be given after every 15 days and should be repeated 3 or 4 times after appearance of the disease.

Harvesting

The harvesting is done after 100–120 days of planting. At this stage the lower leaves start turning yellow. Harvesting is done in bright sunny weather and is done by cutting the green herb by means of sickle 2–3 cm above the ground. In case of delayed harvesting the leaves start to shed, leading to loss of oil. Second harvesting is done after 80 days of first harvest and third done successively after 80 days of second harvest.

Yield

The yield of fresh herbage depends on planting time and also on the interculture. On an average 40 tonnes of herbage/ha of Japanese mint and 20–25 tonnes/ha of Bergamot mint are produced. This in turn gives 250 and 100 kg/ha of oil respectively. Under good management around 18 t/ha of herbage or 60 kg/ha of oil in spearmint crop is produced.

Extraction of mint essential oil

The distillation of oil is done by passing steam under pressure via the wilted, chopped hay, packed in the distillation stills. The distillation units consist of a steam boiler, charging stills and condenser for cooling the oil carrying vapours. The condenser is kept cool by continuous running of cold water. This empties its contents into a receiver – cum – separator which thus collects the mixture of oil and water. The stills are fitted on both the sides of the boiler. The still has a detachable wide open lid which allows mechanical or semi-mechanical filling. The material is tightly packed to prevent the channeling of steam via it. The still has inlet and outlet of steam for draining of excess water. *S*team gradually passes into the still while the cold water runs simultaneously in the condensers. The pressure of the steam generated is around 100 – 120 lbs/sq. inch. The super heated steam takes almost two hours to completely exhaust the hay of its oil depending upon temperature and moisture of the hay inside. The distillate is permitted to flow at a temperature of 105-115°F which facilitate easy separation of the oil and water. Once the material inside is heated and stays about 15 minutes, after passing the steam the oil-water mixture starts flowing into the receiver then the steam pressure can be lowered. The steam should be passed slowly and then should be increased gradually. In this way 80% of oil is received in first half of the distillation period and rest later on.

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Champaka

[*Magnolia Champace (L.) Baill, se Prerie syn*]
Michelia champaka Linn.)

Champaka (Magnoliacea) is also called Champac, Champakakuning, Bunga Cempaka Kuning (Ismail Saidin, 1993), Nama Thai Champi, Champaa

Origin and distribution

Champaka tree has ivory, light yellow, yellow-orange or white flowers that offer very pleasant scent. This tree could be planted as a roadside tree (Corner, 1940 and 1952) or in a smaller garden, being a slower grower. The champaca flower, with it's very unusual floral scent, grows in Nepal, India, Malaysia, and Indonesia. It is a sacred oil to both Buddhists and Hindus. For centuries the oil from the flower has been used in the unique perfumes of both China and India. Champaka is also commonly used to scent ceremonial incense.

Description of plant

Champaka is a large tropical evergreen tree with light yellow, yellow-orange

Champaka

or white flowers. In native lands it blooms in April and May then fruits in July and August. Variety alba is a robust growing tree. These trees have soft wood and are liable to be broken easily, hence, they are not grown near a house. It has large beautiful glossy green leaves. On maturity, it may reach 30-35 feet. It has no pests and is evergreen. The 'alba' does not set seed in growing areas nor do cuttings sprout roots. Seeds have pink, reddish or brownish - reddish colour.

Genetics and breeding

Arora (1987 and 1998) stated that genetic diversity also occurs in the Indian subcontinent in ornamental trees, shrubs, climbers, herbs, succulents, etc. including champaka (*Michelia champaka*). There should be development of high yielding variety resistant to biotic and abiotic stress and reduction in size of plant for easy management practices.

Varieties

- Alba (alba in Latin is white) or creamy white of course has small white blooms or creamy white blooms which are extraordinarily fragrant, is of world fame. Its perfume is the world's very expensive perfume. Like Ylang-Ylang this has ultra exclusive scent. On warm humid nights, the scents of Alba can easily be enjoyed several hundred feet away. Even just driving in car the scent can be experienced. As the scent exudes from the tree nectar insects appear frantic, driven like drug addicts, bashing into each other to get to the heart of every flower on the tree The 'alba' is a robust growing tree. It has large beautiful glossy green leaves. It has a rounded shape. On maturity, it may reach 30-35 feet. It has no pests and is evergreen. The 'alba'does not set seed in growing areas nor do cuttings sprout roots.
- The orange or yellowish champaka, of course is not so fragrant, Because the orange champaka sets seed, it is considerably more available.
- It is even more intensely fragrant than 'alba' while blooming almost all year around. The flowers are 4-5 times larger than 'alba', but not in South Florida where they appear about 3 times larger. The scent from the flowers is so strong that people can't believe it's from a tree.

Parts used: Flower, essential oil, seed, leaves, juice, bark and wood.

Uses

- The tree is commercially used for perfume production in Philippines, India etc. Its oil is available as concrete and absolute. Pure absolute from fresh flowers is used to manufacture high grade perfume. There is a new perfume named J'adore which uses this tree for fragrance.
- In Indonesia, the tan to white medium-hard wood is used for carvings.

It is prized because a bitter alkaloid in the tissues makes the wood insect resistant. It is also used for planking, doors, furniture, canoes, and house-building.

- In other native countries, the tree's leaves, juice and bark are used by locals to cure problems including conjunctivitis, dandruff, lice and worm infections.
- Champaka is also used to control gastritis, chronic arthritis, emmenagogue and diuretic.
- Medicinal Plants of Thailand describe the dried flower as an ingredient of Ya Hom, and used as cardiac tonic, nerve tonic, blood tonic, anti nauseant, anti-pyretic, diuretic. Leaf; treatment of neural disorders. Stem bark; anti pyretic (Promjit Saralamp, 1996)

Cultivation technology

Champaka can be cultivated by seed or by vegetative method.

By seed: Fresh, ripe seeds have to be treated with a fungicide. Germination is fast with seed soaking. Soak in pure clean water. Rinse away water after three hours and discard the water. One or two seeds are planted in 6 × 6 inches polythene bags filled with a mixture of soil and farm yard manure (1: 1). Use a pencil to make10-12 holes in the bottom of each. A hot and humid location is the best, in or out of the sun. Water is needed lightly to keep moist. Do not let soil top dry. Indoors, in a cool or cold-dry or dark home is a miserable environment to sprout the seeds. Warm to hot weather and high humidity will stimulate sprouting. However, the seeds are somewhat slow to sprout, so 6-10 weeks time will be required.

The day seeds sprout, move them to a hot, humid environment, such as outdoors in sun or very light shade. Morning sun is always the best exposure. Morning sun is not a requirement, but sun is required. Arrange a minimum of 6 hours as a good amount of time to get sun. Blazing hot direct sun should be avoided for too long. One can check on root mass whenever it is time to transplant. First cut the bag then invert the plant and soil into hand. If the tap root and feeder roots look like they want more room, this is the time to transplant at the permanent location. Organic soils with up to 50% sand will work just fine.

In 2-3 years the first blooms appear. Blooming will improve every year. A maturing tree over 365.76–457.2 cms will begin blooming more than once a year. Mature trees will hold some flowers almost all year long with bursts of heavy blooming during warm-hot weather months.

By vegetative method: Variety Alba does not produce seed. Propagation from cuttings does not work either. The outcome is that the only way to have an 'alba' perfume tree is by grafting. The 'alba' scion is grafted onto the orange root stock and then, one can have the 'alba' champaka to enjoy.

Narayana Gowda and Nage Gowda (1989) reported that propagation of champaka can be done by soft-wood-wedge grafting.

Plant protection

Occurrence of disease 60% in rainy season 45% in winter and 13% in summer. Leaf spot (Shivanna, 2005) reported that the fungus *Cadosporium* sp. causing leaf spot disease can be controlled by spray of proper fungicide.

Harvesting

Harvesting of flowers is normally done from April to June. Freshly harvested flowers should be immediately shifted to essential oil extraction plant.

Extraction of essential oil

Essential oil from fresh flowers of Champaka are extracted by solvent extraction technology by Sawari Agro chem.

Sahakar Nagar Pune-9, Maharashtra, India is a manufacturer having own processing unit and a 10 acres farm. There is a consistency in quality of the product.

Economic viability

Cultivation of champaka is very viable economically because champaka red absolute by solvent extraction, sells @ ₹ 15,5,000 per 1000 gm and champaka white absolute by solvent extraction, sells @ ₹ 16,5,000 per 1000 gm. Cost of production is not high.

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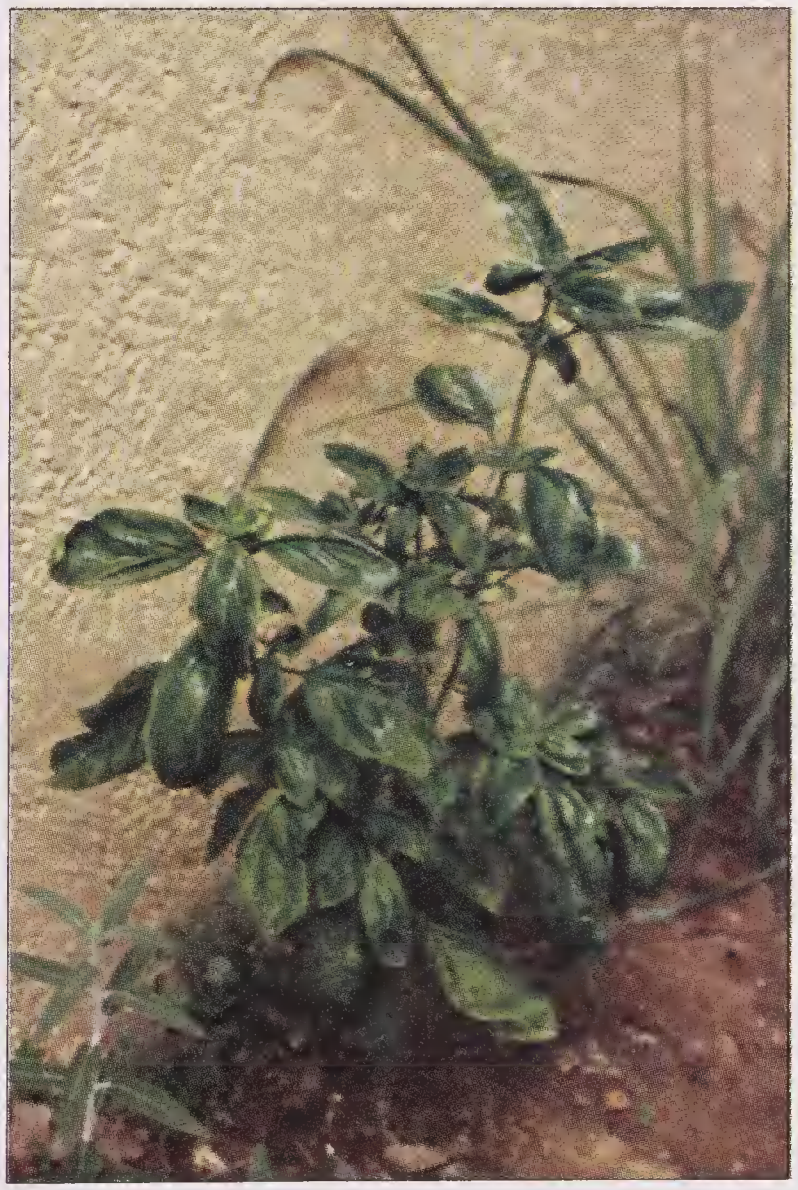
Sweet basil

(*Ocimum basilicum*)

Sweet basil (Labiateae Sub family: Ocimodeae) is also called Basil and French Basil. Barbari**.** Tulsi. Babuyitulsi, Kamakasturi, Sajjagida, Tirunittru and Tiruniruppaccai.

Origin and distribution

Sweet Basil is spread over the tropical, sub-tropical regions of both the hemispheres ranging from sea level to 1200 ft high. Africa has 59 sp. of Ocimum, South Africa has 19 species, Arabia have 11 species, Brazil with 11 species, India having 9 species. These are also found in warmer northern parts of Australia and Philippines. The Ocimum was introduced in Europe from India in 15th or 16th century by Arabs. *Ocimum basilicum* var *glabratum* (French basil) is the only species of *Ocimum* cultivated on large scale. The places of



Sweet basil

its cultivation are France, UK, USA, Reunion, India and some countries of Africa, Brazil and China (Farooqui and Sreeramu, 2001).

Description of plant

It can be shrubs, undershrubs or herbs, and can be biennial, triennial or perennial in habit. The plant is quite branched. Usually the stem and twigs are quadrangular. Young twigs can be greenish, purplish or brownish in colour. The leaves are exstipulate, usually opposite and decussate. The leaves are simple, petiolate, ovate or subovate with serrate or entire margin. Leaves, stem and inflorescence have glandular hairs which secrete strongly scented volatile oil.

Flowers are small and are arranged in whorls on a spicate or racemose inflorescence. Bracts are small, petiolate or sessile. Pedicels are curved. Flowers are hermaphrodite, zygomorphic and complete. Shape of calyx is characteristic. Upper side of calyx tube is broader. The sympetalous corolla is bilabiate which is characteristic of family Labiatae as a whole. The aestivation is imbricate, 4 stamens are declinate with filaments free. The disc is entire or 3-4 lobed. The gynoceium is superior and bicarpillary, though the ovary is tetralocular. Fruits have four 1-seeded nutlets enclosed in the enlarged membraneous, strongly veined recurved calyx. The seeds are mucilaginous, usually being non-endospermic.

Genetics and breeding

Chromosome number of *Ocimum basilicum* is 2n=48 (Sobti and Pushpangadan, 1975). Pushpangadan (1974), Sobti *et al.* (1976) and Sobti and Pushpangadan (1977) carried out detailed cytological research on the genus Ocimum. They presented data on various characters, i.e. chromosomal counts, karyotype, floral biology, breeding behavior, compatibility relationships, experimental hybridization and production of intra and inter specific hybrids, induction of auto and allopolyploids and inheritance pattern of essential oil constituents of six species of Ocimum. Sobti (1976) reported genetical basis of chemical constituents of *Ocimum basilicum.* Pushpangadan (1974) found that there existed considerable differences in several morphological characters. Some of these characters are of great diagnostic value for the identification of the species. He has correlated these morphological differences with those of the chromosome karyotypes. On the basis of these cytotaxonomical investigations, he divided the genus Ocimum. In case of Basilicum, he observed herbaceous habit; petiolate bract; more conspicuous flower; seed being black, ellipsoid and becomes mucilaginous when wet.

In *Ocimum basilicum* cross pollination is more common. To some extent self pollination also occurs. The *basilicum* reveals interspecific crossing and production of hybrids when they are brought together. These interspecific

hybrids are either completely sterile or with partial seed setting. The hybrids could be divided into two types (i.e. completely sterile and partially fertile hybrids) on the basis of degree of sterility of the interspecific hybrids. All the interspecific hybrids produced exhibited some abnormality during meiosis. The major abnormalities encountered were impaired chromosomes at diakinesis and metaphase -I, partial or loose pairing, precocious separation of bivalents, abnormal division of univalents, failure of complete terminalization resulting into non disjunction and bridge formation and formation or restitution nucleus and micronuclei.

The methods suited for breeding better strains of *Ocimum basilicum* are: (*i*) Population analysis and identification of promising plants, (*ii*) Study on the genetic basis for the general and specific combining ability of desirable traits and (*iii*) Recurrent selection and polycross of selected line to produce synthetic seeds.

The criteria for selection of plants for polycross methods of breeding are to be based on the target characters like herb yield, high oil yield, desirable oil combination, etc., Breeding programmes should normally involve breeding of selected lines followed by recurrent selection to develop the polycross hybrid seeds. Breeding strategies may combine both the conventional and modern molecular techniques to effect a genetic response for higher yield as well as better quality of desired composition etc. are some more aspects of the genetic upgrading.

Varieties

- *Vikarsudha:* It is a hybrid variety released from the Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow. Developed by hybridization between exotic basil from Australia (EC331886-CSIRO No. L.6323) and a local adaptive land race referred as Badaun local. It yields 37.3 t/ha of herb and the oil content is 0.7% and the oil yield is 265 kg/ha.
- *Kusumohak*: This variety was released from the CIMAP, Lucknow from seed raised progeny of the introduced strain from Argentina. In this plant, the yield of linalool is high which is about 46% while moderate amount of chavicol (38%) is also present. The yield is 134 kg/ha.

Uses

- The essential oil of *Ocimum basilicum* is used in flavouring medicines.
- The essential oil finds application in perfumery and the leaves in flavouring of food.
- They are considered to be potential against carcinogenic hazards of synthetic chemicals.
- The plant showing no side effects, also freshens the ecosystem.

- *Ocimum basilicum* have been considered to be very safe insect controlling agent and also acts as chemosterilant.

Parts used: Leaves, tender shoot, flower and essential oil.

Chemical constituents

Chemical profile of essential oil given by Pushpangadan and Bradu (1995) is mentioned below:

Varieties	Essential oil *** identified by TLC and GLC		
	Major	Minor	Traces (Less than 1%)
Ocimum basilicum l. var *minima* Benth.	G (45%), Eu (25%)	L, Mch, 1,8C1, Oc, P-cy, C-oo	α-ρ, Lm, B, El, ME, EC.
Ocimum basilicum L. var *glabratum* Benth. (Chemotype No. 1)	Mch (38%), L (35%)	1,8. C1, b-Ca, G-Eu, p-cy, B-E1.	a-r, b-r, Lm, Oc, L-ac.
Ocimum basilicum L. var purpurascence Benth.	Mct (20%), L (60%)	β-ac, α-ρ, Mr, Eu, 1,8C1.	β-ρ, 4-Tr, Ct; Cph, β
Ocimum basilicum var *trysiflora* Benth	Mct (45%), L (60%)	α-ac, β-Ca, β-E1, G-ac,	G, a-r, b-r, Mr, Lm, Oc, G.
Ocimum basilicum var *crispum* Benth.	Mch (50%), L (28%)	α-ρ, Oc, p, β-Ca, G, Eu.	Mch, β-ρ, Mr, anl.
Ocimum basilicum var Darkapal	G (35%), L (35%), Eu (25%)	1, 8C1, B, Ct, Ant.	Th, y-Gd, 4-Tr.

Expansion of chemical names

Ant: - Anetheol; B: - Borneol; B-ac: - Bornyl acetate; Cph: -Camphor, Y-Cardinol; B-Ca: - Carene; Cao: - Caryophyllene Oxide; Ctl: - Citronellal; Ct: - Citral; 1,8C1: -1,8 Cineol; p-Cy: - p-Cymene; β-El: - β-Elemene; EC: - Elemicine; Eu: - Eugenol; G-Geraniol; G-a/G-ac: -Geranyl Acetate; Lm: - Limonene; L: -Linalool; á-ac: - Linalyl acetate; Met: - Methyll cinnamate; Mch: - Methyl Chavicol; ME: - Methyl Eugenol; Mr: -Myrcene; Oc: -Ocimene; α-ρ: - Pinene; r-Tr: - r Terpineol; Th: - Thymol y-Crd: - y Cardinol.

The major oil constituents of *Ocimum basilicum* consists of various terpenes and phenolic compounds. The major oil contents are linalool, camphor, geraniol, citral, methyl cinnamate, methyl-chavicol and eugenol. Linalool,

camphor, citral and methyl chavicol are found as a single major constituents of some types of *Ocimum basilicum*.

Cultivation technology

It can be grown on variety of soil and can tolerate varied climatic conditions. Soil may be from rich loam to poor laterite, saline and alkaline to moderately acidic. Water logged soils should be avoided. Heavy rainfall and humidity is good for plant growth. Oil yield is increased in the long day and high temperature climatic conditions. The crop can be grown annually from the middle of February to the end of September and also during *kharif* season in the plains of north or south India. The ploughing is done 2-3 times, FYM may be added to the soil at the rate of 10-12 tonnes/ha before ploughing.

The propagation is done only by seeds and the sowing is done in nursery and afterwards transplanted in the field. The nursery should be prepared by adding well rotted farmyard manure and leaf mould to each bed at the rate of 1 kg/m^2 in beds of 1 m × 4 m. Seeds are sown @ 10-15 g/bed and are sown in lines 6 cm apart or broadcast over the beds. The seeds are covered by the dusting of soil. The watering is done immediately after sowing and is repeated after 3 to 5 days as per need. The transplantation of seedling is done when the plants attain the height of 8-10 cm.

Transplantation is preferably done in the evening with an interspacing of 100 cm in rows 60 cm apart. Cloudy weather and fine drizzle are considered to be an ideal weather condition for transplantation.

Plant protection

- The larvae of leaf roller among pests causes serious damage to the leaf by sticking to the lower surface of leaf. They are controlled by spraying Thiodon or Malathion (2 ml/l) with water.
- Leaf spot disease is caused by *Coynespora cassicola* (Berk & Curt) Wie. Scab disease caused by *Elsinoe arxii*, causes little defoliation and distortion of twigs.
- Blight of Basil caused by *Alternaria* sp. affect leaves. *Colletotrichum capsici* also causes leaf blight. Both these can be controlled by spraying 0.2% Dithane Z-72 or Agallol.
- Basil wilt caused by *Fusarium oxysporum* affects the whole plant. This disease can be controlled by dipping the seedlings in a solution of Tafason or Agallol at the time of planting.

Harvesting

The lower leaves start turning yellow signifying that the plant is ready for harvest. Harvesting is done by sickle. During harvest the flowering tops and whole herb is cut. On the basis of parts harvested, two types of oil are extracted,

i.e. herb oil and flower oil. The flower oil has a superior note. The highest oil quality is obtained by harvesting only flowering tops. Normally 3-4 floral harvests are obtained in this crop. First harvest is done at the full bloom of plant and then subsequent harvesting is done after every 15-20 days interval. Finally the whole plant is harvested about 15 cm from the ground level leaving enough for the regeneration of the crop. The harvested crop is dried in the field for 4-5 hours so that it looses moisture.

Yield

The floral harvest yields about 3-4 t/ha of flowers and the final harvest of the whole herb is about 13-14 t/ha (Farooqui and Sreeramu, 2001). The sweet basil oil yield will be about 30-35 kg/ha from the flower and 12-22 kg/ha from the whole herb. If only the whole herb is harvested and distilled, the oil yield is about 30 kg/ha.

Distillation

The distillation of *Ocimum* should be done after 4-5 hours of drying, though the quality and quantity of oil is not effected upto 6-8 hours after harvest but further delay is not considered good for quality and yield of oil. The oil of basil is obtained by hydro-distillation or steam distillation of the young inflorescence or the whole herb. Extraction of oil through steam distillation is better than extracting oil by hydro-distillation, as it takes less time and also gives better yield of oil. The oil of *Ocimum basilicum* is lighter than water, a smooth flow of condensate is to be assured by inserting a long stemmed funnel, the end turning upwards. Thus, the distillate steaming from the condenser flows first through the funnel and oil droplets rise slowly towards the oil layer where they merge. Water keeps flowing out *via* siphon. Steam-distillation takes 1–1½ hrs to exhaust a charge completely.

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Kewda

(*Pandanus fascicularis* Lam.)

Kewda (Pandnaceae) (Chopra *et al.* 1956) is also called Kewara, Ketki, Gagand, Fragrant screwpine, Dhuli Pushpika, Mugali, Talamachidi, Tazhai, Thalay, Keya, Kedki – Keya and Keori. Kaida, Thala, Kia Mara, Kyad Agegida, Tale Mara and Kyad Agegida.

Origin and distribution

Kewda is found all along the coastal regions in India. Also found in Arab, Iran and Burma. In India it is distributed in Andhra Pradesh, Tamil Nadu, Odisha and Gujarat (Farooqui and Sreeramu, 2001). In Odisha, Kewda is found wildly in Ganjam district comprising Chatarpur, Gopalpur and Behrampur tehsils. Also Balasara, Cuttack and Puri districts possess kewda plant growing

Kewda

widely (Dutta 1995). There are some plantation of Kewda in Badaun, Balia and Ghazipur districts of Uttar Pradesh.

Plant description

Kewda plant is a densely branched dioecious shrub. It reaches up to the height of upto 6 m, producing glaucous-green long acuminate coriaceous leaves with thorny spines on the margin and mid rib. It has an ariel root to support the growing plant. Flowering starts from 5 years of age and flowers till 40-50 years, maximum being at the age of 15–25 years. Male flower is the economically important part because of its highly scented nature. The male spadix is 25–50 cm long with numerous sub-sessile cylindrical spike enclosed in a long white fragrant caudate or acuminate spathes. The spadix of female flower is solitary. Fruit is an oblong or globose, syncorpous, yellow or red when ripe.

Genetics and breeding

Maharana (1993) identified and assembled several genotypes through collection in Odisha state based on colour, size of thorns, plant height and thorn traits. The thornless type possesses slender leaves producing very few flowers. The dwarf type showed spreading growth habit and the plants were distributed under upland situation and were also very shy in flower production. Crop improvement for higher yield of essential oil, early flowering types and resistant to diseases and pests needs due attention.

Varieties

Maharana (1990) has identified 4 good yielding types:

(a) Dark green leaves and large thorns.
(b) Light green leaves and large thorns.
(c) Dark green leaves and small thorns.
(d) Light green leaves and small thorns.

Per year flower production from 25 years old plants varies from 20 to 28 flowers. Aroma ranges from strongly scented to sweet scented.

Kewda and ketaki are commonly cultivated high yielding varieties in India.

Chemical constituents of kewda essential oil

It has Methyl ether or phenyl alcohol–66.68%, Depentene–6.24%, Linalool–19.16%, Phenyl ethyl acetate–4.65%, Citral–1.82% and Steropentene.

Parts used: Flowers for kewda essential oil and leaves and roots for medicines.

Various uses

- The male spadix is used in perfumery for extraction of essential oil.

The principal perfumery products are Kewda water and Kewda attar (essential oil).

- Kewda water finds its uses in flavouring syrups and soft drinks.
- Kewda attar is used in scenting soaps, cosmetics, boutiques, lotions, snuff, hair oils and incense sticks.
- Kewda aroma in pan masala (betel) and zarda (tobacco) is very popular.
- The male flowers are packed and kept in wardrobes and boxes to give fragrance to the stored material.
- Kewda oil is a stimulant, antispasmodic and relieves headache and rheumatism (Chopra *et al.* 1956)
- The leaves of Kewda are used in making fancy articles like mats, hats and bags. It is also used for paper making.
- Fibres from its long ariel roots are very strong and used in making ropes and baskets.
- The terminal and tender buds are also eaten raw or in a cooked form.
- The leaves are used in the treatment of leprosy, small pox, scabies, leucoderma, diseases of heart and brain.
- The juice of inflorescence is useful in rheumatic arthritis in animals.
- The plant is considered as a good soil binder.

Cultivation technology

The plant is grown on a fertile and well drained soil. It is a tropical species and cannot withstand frost. It needs heavy rainfall. Kewada is vegetatively propagated by suckers and cuttings (60–80 cm long and 8–10 cm thick) made from non flowering branches and old stumps. The planting is done from June to August. The spacing is kept 3–6 m depending upon genotype. Organic manuring, interculture, weeding, irrigations etc. should be attended.

Plant protection

Generally kewda plants are not affected by any pests or diseases of serious nature. Though leaf blight disease is seen in plants caused by *Alternaria tenuis* and *Botrydiplodia theobromae*. These can be controlled by spray of proper fungicide.

Harvesting of flowers

At five years of age the plant produces flowers. At this stage it also develops 20–25 ariel roots. The flowering increases with the increase of age. The flowering occurs from July to October. Harvesting is done by hand by breaking stalk with the help of a stick fitted with a hook. Knife is avoided since it damages the flower bud.

Yield

At five years of age on average the production of flower is five flowers per plant while at age of 20-25 years the flowering increases to 20 to 28 flowers per plant. Flower yield of four types of clones classified on the basis of leaf colour and growth of spines were reported. In 25 years old plantations, the clones with dark green foliage produced 20-25 flowers. Clones having light green foliage yielded 24-28 flowers per plant.

Extraction and yield of essential oil

Immediately after harvest of the plants the flowers are subjected to distillation. The flowers of Kewda are processed to obtain the final products as Kewda attar and Kewda water. Distillery consists of many distillation units. Each unit has a big copper still (deg) and an earthen pot (handi) with a side hole. This earthen pot is inverted over the still and connected to a copper receiver vessel (bhabka) through a bent pipe (chonga). The receiving vessel is half filled with sandal wood oil. The outer green spathe of kewda flower are heated with water in the still. The number of spathe is responsible for the quality of the end product. After heating it for 4-5 hours in an open furnace (chulha) Kewda attar is formed. The receiving vessel is half-filled with sandal wood oil, it absorbs the aroma of the vapour to form kewda attar. These receiving vessels are kept cold by keeping them in cold water. At the end of distillation the vessels are disconnected and kept overnight for settling. The water layer at the bottom is separated from the oil through a small outlet at the bottom. The water is used over again for subsequent batches of distillation and this process is repeated a number of times. There is a need to develop better innovative fuel efficient distillation. As much as 7000–10,000 flowers on distillation yield about 1 kg of attar.

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Scented geranium

Pelargonium graveolens L. (Her. ex Ait.)

Scented geranium (Geraniaceae) is also called Geranium, Pannirsoppu and Pannir Patra.

Origin and distribution

Scented geranium originated in rocky slopes of cape provinces of South Africa. Commercial production of geranium was done in southern France since 1800, Algeria since 1847, Reunion island in south-west Indian Ocean since 1880, Shevroy hills of south India since 1915, spread to Nilgiris around 1954 (Armugam and Kumar 1979). The geranium oil is being largely produced in China and Egypt. Some quantity is being produced in India, Algeria, Morocco. In India it is cultivated in Nilgiris, Kodaikanal, Palani, pomological gardens at Coonoor. Now the crop has spread to plains around Bengaluru and Hyderabad.

Scented Geranium

Description of plant

Scented Geranium is highly adaptable and drought tolerant perennial aromatic bushy herb growing upto about 1.2 m. Leaves are alternate, stipulate, simple, broadly cordate or ovate to almost circular, deeply 5–7 lobed, each segment again lobed and toothed, pubescent on both surface and highly aromatic. Inflorescence umbellate. Peduncle terete, hairy and longer than petiole, pedicels shorter than flowers. Bracts free, celiate on outer side forming an involucre. Flowers are pentamerous, bisexual and hypogynous. Calyx free with hairy sepals. Corolla pink, zygomorphic, two posterior petals are larger. Stamens 10 and filamentous. Ovary pentacarpellary and syncarpous. Style hairy.

Parts used: leaves, flowers, tender shoots and essential oil.

Uses

- The rose like smelling oil extracted from the fresh herbage is used in perfumery.
- It is used in scenting soaps as is long lasting and stable in alkaline medium.
- Powders and creams are scented with geranium oil.
- Geranium gives two other products which are used in perfumery, i.e concrete and absolute. Both possess fine smooth geranium odor, softer and more tenacious than that of the distilled oil.
- It blends with all type of scents–floral and oriental and forms the basis of high grade perfumes.
- It may be used to mix with otto of roses and rose attar.
- It is used for flavoring tobacco products, tooth powder and ointments.
- It is used for pharmaceuticals preparations.

Chemical constituents of geranium oil

It contains large amount of alcohol, 60–70% primary citronellol and geraniol esters, 20–30% geranyl acetate geranyl tiglate. Aldehydes and ketones were also detected in the oil (Guenther, 1950). Some constituents of geranium oil are myrcene, cis ocimene, trans ocimene, terpinolene, lis rose-oxide, trans rose- oxide, cis linalool oxide, menthine trans-linalool oxide, caryophyllene citronelyl formate, citonellyl acetate, geranyl formate, nerol citronelyl butyrate, geranyl butyrate, geranyl tiglate, geranyl formate, nerol citronellyl butyrate, geranyl tiglate and phenyl ethyl tiglate. Faraisse *et al.* (1983) used the GC gas chromatograpy data to examine the chemical composition of the oils. There are present several types of geranium oil of which Reunion is one of the best and is commercially called Bourbon Oil. It has high content of citronellol (Sharan Angadi and Kumar, 1995).

Varieties

- Algerian or Tunisian is grown in Nilgiris and is not suitable for wet conditions.
- Bourbon or Reunion is grown in Nilgiris and Annamalai and is more suitable for wet conditions and is preferred in plains (Prakash Rao, 2001).
- Egyptian strain having high geraniol content and is relatively resistant to wilt.
- A clonal selection been developed from Algerian, i.e IIHR-PG-8 by Indian Institute of Horticultural Research, Bengaluru (Vasantha Kumar and Srivastava, 2003). It gives very good yield of oil.
- Hemanti, Bipuli and Kunti are some other varieties released by Central Institute of Medicinal and Aromatic Plants, Lucknow for cultivation in the north Indian elevated plains (Prakash Rao, 2001).
- Kelkar, Ooty are the other varieties available in this crop as good selections.

Cultivation technology

Scented geranium grows well in well drained, light, deep red soils (Khan and Dimri 1961). Geranium can be cultivated as biennial irrigated crop in south India. Geranium is propagated through shoot tip cuttings and rooted stem cuttings during the month of November. After the removal of all the big leaves, 10–15 cm cuttings with axillary leaves and 3–4 terminal leaves are given a slant cut at the bottom, dipped in 0.1% carbendazim, then in 2000 ppm IBA solution and are then planted in such a way that at least two nodes are inside the soil. The watering of nursery bed is done daily. The root cuttings are ready for transplantation after 60-75 days in the field. Partial shade is used for nursery growing.

Land is ploughed, harrowed and planked well for good tilth. The rooted cuttings from nursery are then dipped in 0.1% carbendazim and are planted in the field at a spacing of 60 cm between the rows and 45 cm between the plants during December–January months. Effect of N P and K on yield of oil has been presented by Mani *et al.* (1981).

Plant protection

- In frost prone areas the crop is protected by sprinkling water (sprinkler with 400 psi) every day in the evening or raising smoke at frequent intervals during frost weather (Armugan and Kumar, 1979).
- Root knots are caused by nematodes (*Meloidogyne hapla* and *M. incognita*), Aldicarb 16 kg/ha is found to be effective in reducing nematodes incidence (Armugan and Kumar,1979)
- Even termites attack the crop which is controlled by mixing 25 kg/ha.

- Wilting is caused by many fungi like *Fusarium oxysporum* var. *radolens* (Sarwar, 1973), *Rhizoctonia solani* (Sarwar,1969; Raghvendra Rao and Chaco, 1983; Kalra and Parameswaran, 1988) and *Phythium* sp. (Ranjit Singh, 1958) etc. These are controlled by the application of benomyl at 0.03% plus 0.5% tracel on 2 month old crop and repeating after each harvest. Spraying should be done one month before harvesting and once after harvesting, This brings down the infection from 80-90% (Sarwar *et al.* 1982). Also the spraying of bavistin (0.1%) in the nursery once in a month and after 2 months in the field reduces the infection as reported in Ooty by Narayana *et al.* (1986).
- Leaf blight caused by *Colletotrichum gleosporioides* is controlled by capitol 0.3% spray.
- Tip rot is caused by *Gleosporium* sp. and causes defoliation. The mutant has been developed which is found to be resistant against the disease (Eugene Sebastian, 2001).
- Grasshopper both adult and nymphs cause damage to leaves by making hole. Spray quinalphos 2 ml or carbaryl (Sevin) 2 g/l.
- Leaf caterpillar (*Helicoveropa armigera*)– Larvae damage inflorescence by feeding resulting in foliage loss. For control spray methylparathion 1 ml or endosulfan 2 ml/l.

Harvesting

After 5 months of planting, first harvesting is done. Subsequent harvests are taken at 3–4 month intervals for 2–3 years. During harvesting the tender twigs and terminal portions of the plant are harvested. The crop is sprayed with 0.1% of Benomyl solution and irrigated immediately after each harvest.

Uses

- Geranium oil is used extensively in most major food products including alcoholic and non-alcoholic, beverages, frozen dairy desserts, candy, baked goods, gelatins and puddings.
- It is found to inhibit the growth of several fungi that are pathogenic to humans.
- It also has antibacterial property.
- Dermatitis in hypersensitive individual may be treated by geranium oil which has been reported through recent data that geranium oil is nonsensitizing, nonirritating and nonphotometric to human skin.
- Research work at the Indian Institute of Horticultural Research, Bangalore has shown that the oil exhibits significant nematicidal activity against root–knot nematode, *Meloidogyne incognita* and antifungal activity against *Colletotrichum gleosporoides* which causes mango anthracnose (Eugene Sebastian, 2001).

- Oil of scented geranium is widely used for manufacture of good perfumes.

Extraction of essential oil

The distillation of oil by subjecting herbage to hydro-steam distillation. Distillation equipment consists of boiler, distillation stills, condensers and receivers. Steam is capable of taking out the oil from cells also steam distillation gives better quality oil as compared to hydro-distillations. Herbage should be packed evenly inside the still. So that the formation of steam channels can be avoided and also the yield of poor oil can be avoided. Distillation still is usually made of steel has a perforated metal sheet at the bottom to support the herbage, kept over it. The condenser consists of many copper or stainless steel tubes mounted inside a jacket. It has inlets and outlets for circulation of water. The receiver receives the condensate (oil). The oil is distilled from the herbage. The recovery of oil from the herb is about 0.2%. Since the oil is lighter it floats on water. After the oil is collected water discarded. Distillation of one charge by steam distillation requires about one and a half-hour. Prolonged distillation may decompose the components imparting characteristic odour to the oil.

The oil obtained by distillation should be completely moisture free before storage. The removal of moisture is done by sprinkling anhydrous sodium sulphate at 20-30 g/l. Stir it for 15 minutes, separating the water layer and then filtering it through a filter paper. The oil should be then stored in a suitable air tight and light proof container and stored in a cool place.

Yield

The strain IIHR- PG –8 yields 23–30 tonnes fresh herbage/ha containing 0.25–0.30% oil. Its yield potential is 65 – 90 kg oil (from 3 cuttings)/ha/year. Yield and quality of essential oil are influenced by environmental factors prevailing during harvesting and distillation. Storage of scented geranium herbage beyond 24 hours after harvest at 30 degree Celsius resulted in oil loss of 16%. The geranium crop can be tried to grow in other agroclimatic regions like coastal places of Andaman Islands and Deccan Plateau for better land utilization. Superior varieties with resistance to biotic and abiotic stress should be developed.

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Anise

(*Pimpinella anisum* Linn.)

Anise (Umbelliferae) is also called Aniseed, Sweet Cumin, Jintan, Saunf, Dill and Sulpha.

Origin and distribution

The word pimpinella was derived from Latin word dipinella and the word anisum was derived from Arabian word anysun. Anise is a native of Egypt, Greece, Crete and Asia Minor and was cultivated by the ancient Egyptians. It was well known to the Greeks and was cultivated in Tuscany. Later on its cultivation spread to central Europe. In Britain anise has been in use since the fourteenth century, and has been cultivated in English gardens from the middle of the sixteenth century. However, it ripens its seeds here only in very warm summers, and it is chiefly in warmer districts. It is grown on a commercial

Anise

scale in southern Russia, Bulgaria, Germany, Malta, Spain, Italy, north Africa and Greece. It has also been introduced into south America and India. In India anise is being cultivated in certain pockets of northern and southern states.

Description of plant

Anise is a dainty, white-flowered umbelliferous annual, about 45.72 to 60.96 cms high, with secondary feather-like leaflets of bright green colour. The cultivated plant attains a considerably larger size than the wild one.

Part used: Seeds and whole herb.

Varieties

The commercial varieties differ considerably in size, but the larger varieties alone are accepted.

- The Spanish Anise, sold as Alicante Anise, are the largest and the best adapted for pharmaceutical use, yielding about 3 per cent oil.
- Russian and German fruits are smaller and darker and are the variety generally used for distillation of the volatile oil.

High yielding varieties resistant to diseases and pests should be developed.

Chemical constituents of oil

Anise fruit yields on distillation a fragrant, syrupy, volatile oil from 2.5 to 3.5% of which Anethol, present to about 90 per cent, is the principal aromatic constituent. It has a strong anise odor and separates in the form of shining white crystalline scales on cooling the oil. Other constituents of the fruit are a fixed oil Choline, Acetaldehyde, Alpha-pinene, Alpha-terpineol, Alpha-zingiberene, Anisaldehyde, Anisic-acid, Anisyl-alcohol, Ar-curcumene, Ascorbic-acid, Bergapten, Beta-bisabolene, Beta-pinene, Boron, Caffeic-acid, Calcium, Camphene, Chlorogenic-acid, Choline, Copper, D-carvone, Dianethole, Estragole, Eugenol, Fiber, Furfural, Hydroquinone, Imperatorin, Iron, Isoorientin, Isovitexin, Limonene, Linalool, Magnesium, Manganese, Mannitol, Methyl-chavicol, Myristicin, P-cresol, Phellandrene, Phosphorus, Potassium, Rutin, Scoparone, Scopoletin, Seselin, Squalene, Stigmasterol, Trans-anethole, Umbelliferone, Zinc etc.

Uses

- In Virgil's time, Anise was used as a spice. Mustacae, a spiced cake of the Romans introduced at the end of a rich meal, to prevent indigestion, consisted of meal, with Anise, cumin and other aromatics.
- In Germany and other countries, many cakes have an aniseed flavoring. Anise is also used in flavoring of soups.
- It is largely employed in France, Spain, Italy and south America in the preparation of cordial liqueurs (Delamer, 1861). The liqueur Anisette

added to cold water on a hot summer's day, makes a most refreshing drink.

- The oil extracted from the seed is said to prove a capital bait for mice, if smeared on traps. It is poisonous to pigeons.
- The leaves are useful for seasoning some dishes. Its fungicidal attribute was proved by Singh *et al.* in 1998.
- The essential oil of anise is a good preventive of mould.
- Anise enjoys considerable reputation as a medicine in coughs and pectoral affections. In dry coughs where expectoration is difficult, it is of much value. It is greatly used in the form of lozenges and the seeds have also been used for smoking, to promote expectoration.
- The volatile oil, mixed with wine forms the liqueur Anisette, which has a beneficial action on the bronchial tubes, and for bronchitis and spasmodic asthma. Anisette if administered in hot water, is an immediate palliative.
- For infantile catarrh, Aniseed tea is very helpful. It is made by pouring half a pint of boiling water on 2 teaspoons full of bruised seed. This sweetened is given cold in doses of 1 to 3 teaspoons full frequently.
- The stimulant and carminative properties of Anise makes it useful in flatulency and colic. It is used as an ingredient of cathartic and aperient pills, to relieve flatulence and diminish the griping of purgative medicines, and may be given with perfect safety in convulsions. For colic, the dose is 10 to 30 grains of bruised or powdered seeds infused in distilled water, taken in wineglassful doses, or 4 to 20 drops of the essential oil on sugar.
- For the restlessness due to languid digestion, a dose of essence of aniseed in hot water at bedtime is much commended.
- Anise oil is a good antiseptic and is used, mixed with oil of peppermint.
- Langham (1683) says that for the dropsie, fill a cock with aniseeds and shake well, afterward drink the broth.
- Oil of Anise is also used against insects especially when mixed with oil of Sassafras and Carbolic oil.
- Essential oil is used for flavoring.
- Seeds are used for seasoning cakes, breads, and cookies.
- Leaves used in soups, sauces, and salads.
- Anise can help to induce production of milk in nursing mothers.
- Anise has excellent digestive property (Gangrade *et al.* 1989; Hornok, 1992; and Chevallier, 1996)

Cultivation technology

Anise is propagated by seeds. Sow the seed in light soil in June, where the plants are to remain. When they come up, thin them and keep them clean from

weeds. Allow about ten inches each way. In cold climate seeds may also be sown in pots in heat and removed to a warm site in May. It has light requirements of sun. Water supply and sowing date are two important factors those affect grain yield and essential oil content. (Randhawa *et al.* 1992; and Fazecas *et al.* 1981). Saeed Zehtab-Salmasi *et al.* (2004) based on their experiments have mentioned that for higher grain and essential oil production, and for efficient use of water, anise must be sown early in the spring (April 4 to 16) in Tabriz. Water deficit during stem elongation and umbel appearance reduced WUE in producing dry matter and essential oil, but irrigation disruption during grain-filling period had no significant effect on WUE of anise. The plant flowers in September, and if the season prove warm, will ripen in autumn, when the plants are cut down and the seeds threashed out.

Processing

The fruit, or so-called seeds, when thrashed out, may be easily dried in trays, in a current of air in half-shade, out-of-doors, or by moderate heat. When dry, they are greyish brown, ovate, hairy, about one-fifth of an inch long, with ten crenate ribs and often have attached stalk. They should be free from earthy matter. The taste is sweet and spicy, and the odor aromatic and agreeable.

Extraction of oil

Oil of anise is distilled from the fruits of *Pimpinella anisum* (Anise) and in China from the Star Anise fruit, is colourless, or very pale yellow, with taste and odor like the fruit. The oils obtainable from these two fruits are identical in composition, and nearly the same in most of their characters, but that from Star Anise fruit congeals at a lower temperature. The oil is employed for its aromatic, carminative and stimulant properties. The bulk of the oil in commerce is obtained from the Star Anise fruit in China. The oil extracted from chinese anise oil is harsh in taste

Marketing

According to a recent website M/S Herb India in Tuticorin, Kerala is arranging marketing and export of Anise (*Pimpinella anisum*).

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Patchouli

[*Pogostemon Cablin* (Blaco) Benth. syn P. *patchouli* Pill]

Patchouli (Lamiaceae) is also called Patcholii, Pacholi and Patchpan.

Origin and distribution

Origin of Patchouli is Phillippines, it grows wild in Malaysia, Indonesia and Singapore. Commercially it is cultivated in Indonesia, Malaysia, China and Brazil (Virmani *et al.* 1976). Vasantha Kumar (2001) reported that its cultivation extends in Paraguay, Penang, West Indies, Subtropical Himalayas and Deccan Peninsula. Now to limited extent it is cultivated around Bengaluru, Mysore, coastal area of south India, Bengal and Asom (Vasantha Kumar, 2001). Its cultivation is being extended to Odisha, and Arunachal Pradesh. It may be cultivated in Andaman and Nicobar also. Production of patchouli oil in India is negligible (about 150 kg/year). India is importing over 20 tonnes of patchouli

Patchouli

oil from Indonesia, Malaysia, Singapore and China. The total world production is around 800 tonnes (Farooqi *et al.* 2000).

Description of plant

Patchouli is an erect, branched, pubescent herb. Leaves are ovate to oblong, densely tomentose on both surfaces, petiole 6-8 cm. Stem densely tomentose and swollen on the nodes. Spikes are terminal and axillary. Flowers are small and usually in spikes. Corolla tube is white with purple streaks. Each lip of corolla has two lobes, upper lip is longer than lower lip. Stamens are four. Ovary is four-lobed, superior with two united carpels with a long style arising from center (Cobley and Stele, 1976).

Genetics and breeding

Chromosomal number of patchouli is 2n=34. The strain Johore along with other four strains was evaluated at Indian Institute of Horticultural Research, Bengaluru and Division of Horticulture of University of Agricultural Sciences, Bengaluru. Oil of Johore is light yellow in colour and is of superior quality and odour value. It contains 44.78% of patchouli alcohol. Ratooning capacity was however found to be moderate.

Parts of use: Foliage, flower and essential oil.

Uses

- Essential oil is mainly used in the perfume industry.
- Patchouli oil has strong fixative property and helps to prevent rapid evaporation of perfume and there by promotes tenacity.
- It is used in a wide range of soaps, body lotions, pre-shave and post shave lotions.
- On blending with sandalwood oil it gives one of the attars widely used in soaps, cosmetics, tobacco and in candescent sticks.
- Dry patchouli leaves may be used for scenting wardrobes.
- The leaves and tops are used in water for taking bath due to its anti - rheumatic action.
- Decoction from the leaves with other drugs are used to treat cold, headaches, vomiting, nausea and diarrhoea (Leung, 1980) in China.
- An allied species *P. heyneanus* is reported to have anti-cancer property (Purushothaman *et al.* 1985).
- Patchouli oil is extensively used as a flavor ingredient in major food products including alcoholic and non alcoholic beverages, frozen dairy desserts, candy baked goods, gelatin, meat and meat products.
- Due to its insect repellent action, it has been used to drive away mosquitoes, ants, moths, flies, gnats. To prevent woollen clothes and expensive dresses from ravages of moths and insects, it is used in

wardrobe, almirah etc.

- All over orient commonly used for poisonous snake bites and stings of various animals, mosquitoes etc. In case of poisonous snake bites like cobra, etc. 100% pure oil is put on cotton/cloth and applied on the bitten surface immediately as first aid and until reaching to the doctor or find instruments to cut and clean the wound. After that 50% oil mixed with 50% of any base oil such as cold pressed sesame, coconut, sweet almond, grape seed, wheat germ or sandalwood oil is mixed and applied twice daily until the wound gets completely healed. In case of stings of various animals, bugs, mosquitoes 25% oil mixed with 75% base oil could be applied until it gets normal.
- It has a unique quality of cell regeneration on the skin as well as kills bacteria, mask bad odoor of the wounds and helps healing it.
- Due to its antifungal action, it has been used for skin infection, eczema, ache, swelling due to infection, specially cracked skin scar tissues and cracked foot collect athlete's foot.
- It has excellent qualities of diruretic, carminative, antiseptic and antiinflammatory.
- It is good as antidandruff. Take any herbal shampoo, use one gram patchouli oil, mix it with 20 grams shampoo and keep it. During bath/ shower apply it on your head as well as hair and massage it for a few minutes all over the skull. It will not only kill dandruff but also help skin of the head to grow thick and strong hair. It also helps to keep hair in its natural color, preventing them from getting grey.
- In scanty urine, ½ drop oil mixed with 4 gram basil seeds powder (*Ocimum basilicum*). This powder has been divided into 3 parts and given three times in a day after meals. It cleans the system and calms down excessive heat of the body.
- In Philippines an infusion of the fresh leaves is given in menstrual troubles.
- The juice of leaves are used to repel leeches.
- Its use is said to cause sometimes loss of appetite and sleep and nervous attacks. The Chinese, Japanese and Arabs believe it to possess prophylactic properties.

Varieties

Five imported cultivars have been tested for several years at the Division of Medicinal and Aromatic Crops, Indian Institute of Horticultural Research, Bengaluru. The imported cultivars are: Singapore,Johore, Indonesia, Java, Malaysia.

Among the five exotic cultivars tested, Java and Singapore strains showed higher herbage yield while the oil content was less. But the Johore, Indonesian

and Malaysian strains showed higher oil yield of good quality.

Industrial tests have revealed that Johore is the best of all and therefore has been recommended to farmers for commercial cultivation of patchouli (Vasantha Kumar and Srivastava, 2002). Higher yielding varieties with resistance to diseases and pests should be developed.

Chemical constituents of patchouli oil

Oil of patchouli is thick, the colour being brownish-yellow tinted green. It contains coerulein, the vivid blue compound found in matricaria, wormwood and other oils. Oil of patchouli contains 40–45% of alcohol. This constituent is not responsible for the aroma of oil. A ketone with orris like smell, other two bases possessing a strong benumbing odour, ozulene and a sesquiterpene alcohol, β–patchoulene, terpene, cadinene, benzaldehyde and patchouli alcohol have been found in small amount by chromatography (Guenther, 1952; Bates and Slagel 1962; Koul and Nigam, 1966). A crystalline fraction of sesquiterpenic alcohol patchoul phenol have been identified. It is levorotatory, with the specific gravity of 0.970 to 0.990 at 15°C. (59°F.). Patchouli oil is soluble in paraffin oil, fixed oils and alchohol. It is insoluble in water.

Cultivation technology

Pathchouli is a hardy plant and can be cultivated in a wide range of soil and climatic conditions. Plant grows best in damp and warm climate with evenly distributed rainfall from 1,500–3,000 mm/annum with a dry spell no longer than 12–14 weeks. Successful cultivation is also possible in plains at low altitude, provided planting is done on ridges ensuring proper drainage in the field. pH of soil should be about 6.5. Humidity of 75% is ideal for patchouli. It grows successfully upto an altitude of 800–1050 m above sea level.

Propagation

The crop flowers under NE conditions but does not set seeds due to sterile pollens hence propagated vegetatively by stem cuttings. Propagation is done through (i) rooted terminal cutting and (ii) tissue culture plants. This is the reason why quick propagation of the plant is not possible and extension of plants on commercial scale is slow. The cost of planting material makes the cultivation cost quite high which may often lead to less return in first year. Propagation by cutting is generally preferred.

Nursery raising and transplanting

Stem cuttings from 9 months old branches of 10–12 cm length consisting of 4-5 nodes especially with the terminal bud and crown of 2-3 leaves are quite suitable. The basal end of the cutting should be neatly cut in oblique form just above 1 cm below the node. Treatment with 1500 ppm indole butyric

acid of the basal end encourages rooting. The cuttings should then be planted in nursery beds with the help of dippler at a spacing of about 10 cm or in 6 × 6 inches polythene bags. The cutting takes about 30 days for rooting in nursery and in about 10 weeks they are ready for transplantation.

The field before transplantation is thoroughly ploughed and levelled. Furadan @ 20 kg/ha (3% a.i) is mixed well into the soil a few days before transplanting. Then ridges and furrows are formed. The ridges should be 25 cm high and 18-20 cm broad with 60 cm row to row distance. Plantation is done at the space of 60 cm in rows. Transplantation in July–August result in about 90% establishment.

Manure and fertilizers

Ten cartloads of FYM is mixed at time of field preparation. Before transplanting 25 kg nitrogen, 50 kg phosphorus and 50 kg potash should be applied. Thereafter nitrogen is given in 5 split doses after every harvest in such a way that the crop receives first dose just after the harvest and other dose after 2 months. In total, 150 kg nitrogen is applied to the crop.

Plant protection for patchouli:

- Leafblight disease is caused by *Cercospora* sp. on margin or top and can be controlled by giving two sprays of Dithane Z-78 (0.5%) at monthly intervals (Sarwar *et al.* 1983).
- Fungus A*lternaria alternata* (Fr) Keissker also found to infect the plant and can be treated by using fungicides dithane M-45 and captan.
- Wilting disease is caused by *Rhizoctonia solani* Kuhn. In this roots and collar region of fully grown plant blackens and dies.
- Viral disease yellow mosaic has been found affecting the plant. Such plants should be uprooted and burnt.
- Caterpillar and leaf webber are the two pests attacking patchouli plant. They can be controlled by spraying metacid at 2% or methyl parathion (Raghupathy *et al.* 1979; Sarwar *et al.* 1983).
- Root knot of patchouli caused by a nematode *Meloidogyne incognita* can be controlled by suitable nematicides and proper crop management practices.

Distillation of oil

Extraction is done by steam distillation process. The dried herbage is put nicely into the herbage chamber of the machinery and steam is passed under particular pressure (25 to 30 pounds/square inch) for particular time (8.5 hours). In first half-hour about 40% oil is gained, rest is gained afterwards. The steam takes away the patchouli essential oil. It passes through the condenser. Steam gets condensed into water and oil vapour get condensed into essential oil. Being lighter than water essential oil floats. Essential oil is then separated and

packed properly for sending to market.

Yield

A good crop yields about 2 tonnes of dry leaves per annum and about 60 kg of oil/ha/annum.

Economic viability

Studies have indicated that in first year net profit is ₹ 42,610 and in second year net profit is ₹ 48,614 as detailed below:

Total cost in first year cultivation and extraction of oil	₹ 21,390.00
Net earning in first year	
64 kg oil yield @ ₹ 1000/kg	₹ 64,000.00
Cost of cultivation and extraction	₹ 21,390.00
Net profit in first year/ha	₹ 42,610.00
Total cost in second year for cultivation and extraction	₹ 15,386.00
Net earning in second year	
Yield 64 kg oil @ ₹ 1000 per kg	₹ 64,000.00
Cost of cultivation and extraction	₹ 15,386.00
Net profit/ha in second year	₹ 48,614.00

Harvesting

An index of harvest is that foliage colour changes from pale green to brownish and a characteristic sweet odour of patcholi emanates. Subsequent harvesting can be taken after every 3–4 months depending on the local conditions. While harvesting, the length of top cuts should range from 50–60 cm. It is necessary to leave 6–8 cm at the basal region for regeneration. Harvesting is done with the help of sharp sickle or secateure. The crop can be maintained for about 2 years. After harvest the material is spread in thin layer for 7–8 days and periodic turning is required for proper drying. Dried material is pressed into bales and stored in cool dry place till distilled. Normally crops have the life span of 18 months. Research should be done to increase its life which may lead to the development of high yielding clones for longer durations.

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Tuberose

(*Polianthus tuberosa* Linn.)

Tuberose (Amaryllidaceae) is also called Gulcheri, Gulshabo, Rajnigandha, Nilasampangi and Sugandharaja.

Origin and distribution

Tuberose was first reported to be cultivated in Mexico (1522). Later on in 16th century it was cultivated in Europe and then it spread to India and Sri Lanka. Tuberose is grown largely in southern states of America, Italy, France, South Africa, Taiwan, Egypt and in many tropical and subtropical areas in the world. In India, cultivation of tuberose is confined to Ranaghat, Kolaghat and Panskura in West Bengal: Devanahalli, Tumkur and Mysore in Karnataka. East Godavari Guntur, Chitoor and Krishna Districts in Andhra

Tuberose

Pradesh; Coimbatore in Tamil Nadu and Pune and Thane in Maharashtra. Highly priced scent 'poison' is made exclusively from tuberose essential oil.

Description of the plant

Plants of tuberose are small structured arising from tuberous rhizome. Leaves are basal long narrow and very dense. Flowers are bisexual, usually paired, appear in long simple terminal racemes. Perianth tubular or funnel shaped. Perianth tube cylindrical expanded at top. Stamens are six in number on the perianth and anthers are dorsifixed in the middle. Ovary is trilocular with numerous ovules having three stigma. Fruit is a capsule, crowned by the persistent perianth. Seeds are flat.

Genetics and breeding

Tuberose has the characters of dichogamy and self incompatibility. Crosses between 'single' and 'double' varieties produce fruits and seeds, if the pollination is done within 3 days of flowering in female flowers. If the stigma is pollinated at the bud stage till the first day of flower opening, the pollen tube does not develop. However, the pollen tube develops normally if the pollination is done after 3 days of flower opening. Crosses between 'single' and 'double' varieties produce fruits and seeds. On selfing neither double varieties nor single varieties produce any seed due to incompatibility. However, it has been found that several single varieties produce seeds on selfing.

Parts used: Flowers, leaves, bulbs, roots and essential oil.

Uses of tuberose

- Tuberose is an ornamental plant. The flowers are utilized in decorations.
- Tuberose flower oil is one of the most sought after and expensive perfumery raw materials. This otto mixes with other essential oils.
- Tuberose oil is used to flavor candy, beverages and baked foods.
- The oil has been found to be added in the items like non-alcoholic beverages like ice-creams and candy.
- The alkaloid present in the tuberose bulb causes vomiting.
- The bulbs are considered to be hot, diuretic and emitic.
- The bulbs are dried and powdered and used for treating Gynorrhoea. (Watt, 1892)
- The bulbs are rubbed with turmeric and butter and applied as a paste to remove small red pimples of new born babies.

Improved varieties of tuberose are:

- Shringar: it is single type, yield about 16 tonnes of flowers/hectare containing over 0.1% concrete. It was developed by the Indian Institute of Horticultural Research (IIHR), Bengaluru.
- Prajwal: It is single type. Yield is slightly more than Shringar. Released

from IIHR, Bengaluru in the year 2000. It may be used for extraction of essential oil.

- Suvasini: It is double type and preferred as ornamental type. It is a variety having excellent yield developed by IIHR, Bengaluru.
- Single: Its flowers are pure white with only one row of corolla segments. It is preferred for production of essential oil. Concrete content is about 0.1%
- Semi-double: Its flowers are white with two to three rows of corolla segments. It is a floricultural variety.
- Double: Flowers of this floricultural variety are white having more than three rows of corolla segments.
- Pearl: Flowers of this floricultural variety are tinged with red in 'Double'.
- Variegated: This floricultural variety has beautiful streaked leaves.
- Rajat rekha: It is an Indian mutant in which a single flower type with silvery white streaks placed along the middle of the blade. It is a floricultural variety.
- Swarna rekha: This floricultural variety is an Indian mutant having the flower of double type and the leaf margins are streaked with golden yellow.
- Coloured tuberose types: IIHR, Bengaluru has developed light pink, light green and yellow buded strains. These are new ornamental types developed for first time in Asia. However, the yield of flower in this plant is low. (Srivastava, 2002).
- High essential oil tuberose: In an ICAR adhoc research scheme in Indian Institute of Horticultural Research, Bengaluru a strain was developed which produced almost 0.25% concrete. However, this strain had very poor yield of flowers (Srivastava, 2002).

For growth of export there is need to breed tuberose for high essential oil content, its high quality and resistance to diseases and pests.Other floricultural varieties are albino and exelsor.

Chemical constituents of essential oil

Tuberose essential oil is found to have methyl benzoate, methyl anthranilate, benzyl alcohol, benzyl benzoate, butyric acid, phenyl acetic acid, methyl salicylate, eugenol, geraniol, nerol, both free and as acetates and farnesol. Methyl vanillin and piperomel is also found.

Cultivation technology

Tuberose plant is sun loving. It grows well in tropical and subtropical climate. Ideal temperature is 20-35 degree centigrade. Over 40 degree centigrade as well as low temperature and frost damages the plants and flower

quality. In mild climate, free from extremes of high and low temperature it can flower throughout the year. Tuberose is susceptible to wide range of soil varying from light sandy loam to clay loam. For tuberose at least one and half feet deep well drained soil rich in organic matter with good water holding capacity, pH ranging from 6.5- 7.5 is preferred. It is susceptible to poor drainage conditions. The soil is exposed to sun during first ploughing. About 40 tonnes of farmyard manure is mixed well in soil uniformly and second ploughing is done one month before planting. Harrowing and cultivator are run cross wise and field is well leveled.

Multiplication of tuberose is done commercially by bulbs. Spindle shaped bulbs of average diameter of 1.5 cm or above free from disease should be used for planting. Large bulbs (3–3.5 cm diameter) results in better quality and yield of flower. Under Bengaluru and Mysore conditions it can be planted throughout the year but to obtain highest flower yield April-May planting is the best. Bulb should be planted at about 1 cm depth at a distance of 15 × 20 cm. It results in 3.33 lakh plants/ha. These sprout in about 10–15 days. Tuberose needs somewhat more irrigation. Interculture, weeding, manuring must be attended.

Harvesting

Fully open flowers are harvested early morning and taken to extraction house for extraction by organic solvents.

Yield and price

In first two years the variety Shringar (single type) yields about 16 tonnes loose flowers/ha/year. In third year flower yield remains about 10 tonnes per hectare. Yield of spike is about 5 lakh spikes/ha. Yield depends on agroclimate and field management. Price of tuberose absolute is ₹ 1,00,000/kg.

Plant protection

- Aphids and grasshopper attacking the plant can be controlled by spraying 1% of melathion or rogor at the regular interval of 15 days.
- Red spider mites are controlled by metasystox or kelthane spray.
- Thrips attack can be prevented by spraying nuvacron or soil application of thimet.
- Weevil feeds on leaves and this damage can be controlled by the treatment of the soil.
- Root-knot nematodes cause death of the plant. For controlling it timik, thimet or furadon are used.
- Fungi *Sclerotium rolfsii* attack the plant and is capable of causing severe damage to the flowers. For controlling it, soil around the affected stem, should be mixed with brassicol 0.75 W.P. (1% suspension) and Zineb 75 W.P. (drenching soil with 0.3% solution) should be done.
- Leaf spot caused by *Alternaria polyantha*. Spraying of 1% of Bordeaux

mixture, 0.4% of Zineb or 0.5% of Ziram is recommended to treat the disease.

- Spraying of sulphur is done to control the attacks by rusts and powdery mildew.

Extraction of essential oil

The essential oil is extracted from flower of tuberose. The flowers are subjected to processing in extraction machine. The flowers are dipped in food grade hexane for 3 times, i.e. 40 m, 30 m and 20 m. Afterwards, the flowers are discarded. The liquid (miscela) is heated at 60° C. The gasified hexane is passed through a good condenser and collected for reuse. The remaining small amount of thick liquid is passed into a vacuum drier. After drying, the matter is called 'tuberose concrete'. It is a brown coloured waxy material having the true aroma of tuberose flowers. Traces of solvent smell from concrete is removed by the help of vaccum drier. One kg of concrete is obtained from 1,000 kg of flowers normally.

To make the absolute, the tuberose concrete is dissolved in absolute alcohol. At cold temperature of 3°C it is filtered properly. The resultant material is called 'Tuberose absolute'. It is semi-viscous brown coloured material having the true odor of tuberose flowers. Quality parameters of the absolute are determined by gas liquid chromatography. Tuberose absolute is used for blending purpose to make high trade perfumes and other essential oil products. Recovery of absolute is about 40% of the concrete.Tuberose absolute contain methyl benzoate, methyl anthranilate, benzyl alcohol, benzyl benzoate, eugenol, geraniol, nerol, farnesol, methyl vanillin and piperomet.

Marketing

Tuberose concrete and absolute are exported to France, Italy, Europe and Japan. Domestic consumption is negligible. Marketing of this high value product needs proper attention by government. Price of tuberose essential oil is ₹ 1,00,000/per kg.

Economic viability

Tuberose gives good yield for two years. The total cost of cultivation and extraction/ha for the first year is ₹ 4,58,167 gross and the earning/net return in respect to/ha in the first year is ₹ 24,1,833. The total cost of production and extraction in the second year is ₹ 2,88,500 and the earning or net profit/ha is ₹ 5,71,500.

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Damask rose

(*Rosa×damascena* Mill.)

Damask rose (Rosaceae) is also called Tarunipushpa, Atimanjula, Simantika, Khushbu Gulab and Scented Rose.

Distribution

It is distributed in Bulgaria, France, Italy, Turkey, USSR, China and India. In India it is commercially cultivated in Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh (Aligarh, Ghazipur, and Ballia), Rajasthan (Haldighati, Pushkar and Udaipur) and Bihar. Total area in India is about 2500 hectares. More area under damask rose is in northern plains, while north-western Himalayas region are most suitable for its cultivation. Bulgaria and Turkey are leading countries for production of rose oil. Morocco produces mainly rose water. India, Pakistan, Egypt, China, France and the former Soviet Union are among other countries which produce rose oil, rose water, concrete and

Damask Rose

absolute . Approximately 15 tonnes rose oil, rose concrete and absolute are produced annually by these countries. Gulab attar is important in India which is produced by blending of sandalwood oil with rose fragrance (Kaul, 1995).

Plant description

Damask rose is a perennial hardy shrub with a long life span of 20–30 years under cultivation. The height of plant is 2–3 m. Several moderately stout hooked falcate prickles are found on stem, intermixed with glandular bristles. Leaves are compound, stipulate, imparipinnate having 5–7 leaflets. The stipules are adnate. The leaflets are moderately large, ovate to oblong and serrate. Flower is axillary, terminal in corymbose, occurring in group of 5-7. They are of varied colouration from white, pink to red and have a sweet smell. The pedicle possesses densely packed acicular and hispid glands. The sepals are pinnate and persistent. Fruit is pseudobaccate made of several hard achenes enclosed within a succulent calyx tube. The fruits are ovoid, bright red and pulpy. Plants of damask rose has wide adoptability to various agroclimatic conditions. Total life span of damask rose vary from 15 to 30 years including 2-3 years of gestation period.

Genetics and breeding

Rosa damascena is considered of hybrid origin (Chandra, 1995). Genetic studies have revealed that there are two types of damask rose. One type of damask rose got developed from hybridisation of *Rosa galbia* × *Rosa phoenicea.* Other type of damask rose known as *Rosa bifera* has been developed by hybridisation of *Rosa galbia* × *Rosa inoschata. Rosa damascena* is a tetraploid having 2n=28. (Patra *et al.* 1987) reported two morphologically distinct types of rose plants intermixed under cultivation in district Aligarh (Uttar Pradesh). These were dwarf and tall types. Dwarf type have one meter height with short peduncles and drooping habit. It had 150 flowers/bush/year and had oil content of 0.064 %. On other hand tall type was above one meter with long peduncles and straight stem. It had only 30 to 40 flowers/bush/year and had oil content of only 0.03%. Patra *et al.* (1987) have compared evaluation of four clones, ie. RSL 31, 76, 87 and 88 with Bulgarian Rose and RL 19. They have found RSL 31 as the best strain.

Varieties

Several varieties mentioned below have been reported:

- Triginipetala is also called Kanzalik Rose and is grown in Bulgaria.
- Bifera is grown in Kannuaj district of Uttar Pradesh.
- Noorjehan has been developed by the Central Institute of Medicinal and Aromatic Plants, Lucknow.
- Jwala and Himroz have been developed by the Institute of Himalayan

Bioresources Technology (IHBT), Palampur (Himachal Pradesh). These varieties give consistently high flower and oil yield when grown under recommended agronomic conditions.Jwala variety is suitable for cultivation in sub tropical northern plains, mid hills and mild temperate regions upto 1,200 m altitude. Himroz variety is suitable for cultivation in mild temperate to cold temperate regions (1,200 to 2,500 m altitude). It is winter-tolerant and grows in temperate areas without any visual sign of winter injury to flower buds. There is a need of taking up varietal improvement regarding yield and resistance to diseases and pests for different agro-botanic, climatic and soil regions of India.

Chemical constituents of damask rose essential oil

The constituents of rose oil are Ethanol (1.2%), Rose oxide (1.3%), Linalool (2.3%), Rhodinol, Nerol (12.4%), Geraniol (34.9%), Phenyl ethyl alcohol (7.4%), Citronellol (23.9%), Eugenol (1.6%) and some unidentified constituents (15.0%).

Parts used: Flowers for production of essential oil and other products

Uses

- It has an aesthetic importance world wide.
- Rose concrete, rose absolute , rosewater, rose attar, gulkand, gul-rogan, and pankhuri have important uses in perfumery.
- The flower, essential oil and other extraction products are also highly prized materials in the fragrance, cosmetics, pharmaceuticals, nutraceuticals and food industries.

Cultivation technology

Damask rose prefers cold and dry mild temperate climate for producing quality grade rose oil with higher oil yield. It also performs well on foothills of Shivalik range and north Indian plains with adequate rainfall or irrigation. Areas receiving high temperature coupled with high humidity, such as coastal peninsula and other similar south Indian zones are not suitable for Damask rose cultivation.

Damask rose plantations prefer bright sunny conditions and performs better when sun shine is available during whole day, if not at least during forenoon. It can not be cultivated under tree plantation.

Damask rose is propagated through one year old stem cuttings. It can also be propagated by the sub-division of stem, lateral sprouts, water shoots and seeds. Stem cuttings are used for raising nursery at the time of pruning during November–December. The rooting occurs within a year and afterwards rooted cuttings can be transplanted in main field. Planting can be done in monsoon (July/Aug.) but winter season (November–December) is preferred.

The land should be nicely ploughed in April and May. In rainy season the land should be again ploughed, green manured with Dhaincha *(Sesbania bispinosa)* or Sanai (*Crotalaria juncea)*. By the end of October the land is again ploughed and leveled. Afterwards the field is divided into beds of 6 m × 4 m for laying out of irrigation system. Pits measuring 0.3×0.3×0.3 meter should be dug 1 m × 1 m apart. The pits are filled up by mixture of farm yard manure and soil (1: 1). Best time for planting is October to December, however it can be done upto February with availability of irrigation facility.

Irrigations are necessary during dry periods but the frequency can be reduced when the plants get established in the field. About 10 to 12 irrigations/year are required. Proper drainage is required.

A good crop needs 200 kg N/ha in 3 equal doses. Phosphorus @ 50 kg/ha should be applied around main stem of plants at depth of 3 to 5 cm after pruning. Potassium should be applied at the rate of 20 kg/ha around main stem if the soil is deficient in it. Spray of 0.1% urea, 0.4% orthophosphoric acid and agromine every fortnight from end of January till commencement of flowering is supposed to enhance yield of flowers .

Pruning is carried out to maintain the plant of desired size, to remove injured and diseased parts, to remove the terminal buds, to change the growth habit and for taking quantitative yield of flowers (Mansingh *et al.* 2002). First pruning should be done after two years of plantation from second to third week of December. It should be repeated every year. Pruning is done above 50 cm above ground. It takes 70 to 90 days after pruning to flower.

Plant protection of damask rose:

- The die back is due to *Diplodia rosarium* which are treated by copper fungicides. Also the application of Bordeux mixture (2 : 2 : 50) just after pruning helps in controlling it.
- Whitish or greyish spot on leaves are checked by application of cyclohenionide either alone or with combination with sulphur. Dusting with sulfan at 25 kg/ha is also effective.
- Black spot disease is caused by *Diplocarpon resea* and is treated by spraying 2 : 2 : 50 Bordeux mixture.
- Chlorosis of rose leaves are treated with the help of 0.1–0.2% spray of ferric sulphate.
- To prevent the plants from ants soil should be treated with a mixture of 50% DDT at 3g/plant.
- Termites attack can be checked by the application of aldrin 30 EC at 25–30 kg/ha . Aphid attack is controlled by spraying tobacco decoction or Duasion 20 E.C.

Harvesting of flowers

Flowering in *Rosa damascena* occurs only once in a year, that too for only

25-30 days during early summer period, though exact flowering period varies from place to place. Before sun rise, the plant has more concentration of oil, so the plucking of flower should be done early in the morning. Flowers are transferred to well aerated wooden baskets before processing. Piling up of fresh flowers should be avoided to prevent the quality and quantity deterioration. Flowers are processed for different products immediately after harvesting. Heavy losses of oil content occur when flowers are stored for period longer than 4-5 hours.

Yield and economic viability

In India Damask rose is cultivated in about 2000 hectares, mainly in sub tropical parts of the state of Uttar Pradesh and Rajasthan. To improve the productivity of rose flower and oil, CIMAP, Lucknow introduced the Bulgarian clone of Damask rose in the field station in Kashmir in late seventies, which showed the fresh flower yield potential of 7,000 kg/ha against 1,000–1,250 kg/ha of Indian clone cultivated in major rose growing areas in sub tropical plains. The yield of rose flower also depends on the time, height and frequency of pruning. Average flower yield in well managed plantation is about three tonnes/ha/year after third year of plantation. No information is available on total production of rose flower in India. However, according to a report published by HBTI, Kanpur about 10,000 tonnes of rose flowers are consumed for production of perfume products annually in Uttar Pradesh.

Gross return/ha is 1. 25 to 1. 50 lakh/year. Total cost of production is about 0.6 to 0.7 lakhs. Net return is around ₹ 65,000 to 80,000/ha/year.

Extraction of essential oil

Soon after harvesting, the flowers are processed by hydro distillation, by which it yields rose water, attar and otto. The method of hydro distillation includes the suspension of flower in the boiling water. The vapours are then collected by condensation. In India, the extraction is done by firing a copper vessel called 'deg' covered with a cover of copper called "sarposk". The vessel has the capacity of 50 –100 kg of flower. The distillate is collected in a long necked receiver kept immersed in cold water. The receiver is called 'shopka'. The distillation takes place in about eight hours. The rose water is then collected as distillate in the receiver. The flower left after distillation is discarded.

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Sandalwood

(*Santalum album* Linn.)

Sandalwood (Family: Santalaceae) is also called White Sandalwood, White Saunders, Yellow Sandalwood, Chandan, Safed Chandan, Chandanam, Srigandha and Chandana.

Origin and distribution

Sandalwood is one of the oldest known perfumery material and best known of all aromatics (Venkatesan *et al.* 1996), having been in continuous use for over 4000 years. It is a native of Indonesia, is the most valuable species, with the wood containing upto 6% oil. It is currently being harvested from natural stands in India, Indonesia etc. Unfortunately, the resource is being rapidly depleted due to unsustainable harvesting. Sandalwood is a hemi-parasitic plant

Sandalwood

which is widely scattered in dry deciduous forests. In India it is distributed in the dry scrub forest of Salem, Mysore, Coorg, Coimbatore, Nilgiris up to 900 meters altitude. It is also found in Andhra Pradesh, Bihar, Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Tamil Nadu. The finest wood and oil has traditionally come from Mysore, the fabled City of Sandalwood although there is some beautiful oil now coming (in limited quantities) out of the forests of Tamil Nadu.

Description of plant

Sandalwood is a evergreen small tree — a partial root parasite. The wood of its stem, which grows from 12 to13 meters high and girth of 1 to 2 m with slender drooping as well as erect branching. The wood is straight-grained and varies in colour from white when young to yellow or orange when older. Its oval leaves are covered with whitish bloom; its small flowers, varying in colour, grow in numerous cymes. The tree starts flowering at an early age of 2 to 3 years. Fruit is drupe, purplish when fully matured and single seeded. Heartwood light yellowish brown when freshly cut, turning dark brown on exposure, and with further aging, to a dark reddish brown; sapwood whitish. Texture very fine and even; grain straight, sometimes wavy; dull to somewhat lustrous, with oily feel; heartwood with a strong fragrant scent that persists.

Genetics and breeding

Genetic diversity is a key factor in the formulation of effective conservation strategies and germplasm management. Shashidhara *et al.* (2003) reported the RAPD analysis done to determine the genetic variability in sandalwood. The extent of genetic variation and relatedness of 54 sandalwood genotypes procured from different geographical regions of India and western Australia were studied using RAPD markers. Certain rare and genotype specific bands were identified which could be effectively used to distinguish the genotypes. The variation in RAPDs indicated that sandalwood germplasm within India constitutes a broad genetic base. Principal component analysis clearly differentiated the Indian genotypes from those of the Australian genotypes.Results showed that RAPD markers could readily dissect the genetic differences between genotypes thereby enabling the formulation of appropriate strategies for germplasm management and selection of diverse parents for sandalwood improvement programmes. A simple method of using presslers increment borer on live sandal trees for heartwood estimation was done by Kulkarni *et al.* in 1996. Current status and future prospects of sandalwood breeding has been discussed by Srimathi, 1996.

Genetic diversity within and between five Indian sandal provenances, namely Marayoor (Kerala state), Bengaluru, Mandagadde and Thangli

(Karnataka state) and Javadis (Tamil Nadu state), was investigated by Suma and Balasundaran (2004) using metabolic enzymes, viz. peroxidase, shikimate dehydrogenase, glucophosphate isomerase, malate dehydrogenase and esterase. Ten of the eleven resolved loci (90.9%) were found to be polymorphic at least in one of the individuals analysed. Observed heterozygosity, both at the locus and provenance level, was higher than the expected heterozygosity in Hardy–Weinberg expectations. The average rate of gene flow between the provenances was found to be very low (0.069). An examination of the partitioning of genetic diversity within and between provenances indicated that 78.3% of the observed variation occurred between provenances and the rest of the variation within provenances. The genetic relatedness of the five provenances was revealed by the UPGMA dendrogram, which comprised of mainly two clusters. Bengaluru and Thangli were the most genetically similar and Marayoor and Mandagadde were the most diverse provenances. The low degree of genetic variability within *Santalum album* provenances might be due to the fragmentation of a previously large original population, resulting in loss of genetic variation, least amount of gene flow between provenances and differentiation of population due to random drift. Development of high yielding variety resistant to diseases and pests should be done.

Variety: Mysore sandalwood yields best oil.

Parts used: Wood and Volatile oil.

Chemical constitution

Heartwood contains a volatile oil 2.5 to 6%, a dark resin and tannic acid. The constituents of the oil are santalol which is the principal constituent present to 90% or more. It is a mixture of two isomers known as α-santalol and, ß-santalol (alpha-santalol and beta- santalol). The other components are aldehydes and ketones, such as isovaleric aldehyde, santonone, santalone, esters, free acids etc. Alpha- santalol and beta-santalol account for most of the odor of sandalwood oil. Seeds yield 50 to 55% of a dark red viscid fixed oil containing stearolic acid and santalbic acid (Shankaranarayana *et al.* 1996).

Aromatic, medicinal and other uses

- Sandalwood is highly aromatic. It is used to make perfumes, aromatherapy and in flavour industries.
- Sandalwood oil is excellent for the stresses of a hectic life as it helps reduce tension, confusion, fear and obsessions.
- The oil is also widely known to be an excellent aphrodisiac equally useful in cases of frigidity and impotence. It is also an anti-depressant.
- Sandalwood oil was used traditionally to treat skin diseases, acne, dysentery, gonorrhea etc. In traditional Chinese medicine, sandalwood

oil is considered an excellent sedating agent.

- The wood ground up with water into paste is commonly applied to local inflammations, to the temples in fevers, and in skin diseases, to allay heat and pruritus. It also acts as a diaphoretic. In case of morbid thirst the powder of the wood is recommended to be drunk in coconut water. It is popularly used to treat urethral haemorrhage and kidney afflictions. Externally the oil is an excellent application in scabies in every stage and
- Sandal wood oil is antibacterial, antiseptic, astringent, carminative, disinfectant, diuretic, expectorant, hemostatic, sedative, stimulant and useful in acute dermatitis,bronchitis,cystitis and gonorrhea.
- It is useful in Infection, palpitations, sunstroke, urethritis and vaginitis.
- The oil can also be used for bronchitis and for inflammation in mucous tissue.
- A decoction of the wood may be helpful for indigestion and fever and externally for skin problems, especially those of bacterial origin.
- Sandalwood cools and calms the entire body and mind. It affects the circulatory, digestive, respiratory and nervous systems.
- It relieves fever, thirst, burning sensation and stops sweating. It is good for fever or overexposure to the sun.
- Sandalwood is good for most of inflammatory conditions and for cleansing the blood.
- The oil or paste is useful for most infectious sores or ulcers if applied externally.

Bad effects of sandalwood

- Some people may experience severe lung congestion.
- Some people may experience mild skin irritation from application of sandalwood oil.
- Santalol can cause dermatitis in sensitive individuals
- Upset stomach and skin itching have been reported with the use of sandalwood and sandalwood oil (Blumenthal *et al*. 1998 and Liniiger,1998)

Cultivation technology

Soil and climate

It grows in various soils (Kondas *et al.*) subsisting well in clay, laterite, sand, loam and very stony, rocky soil. In fact, trees growing in this kind of soil are known to have more highly scented wood. However, red sandy loam soil is most suited. Sandalwood prefers humid and hot climate.

Nursery raising and planting

Viable seeds are produced after about five years and dispersed by birds (Mangalraj Johnson, 1966). Seed beds are formed with only sand and soil in the ratio 3:1 and are thoroughly mixed with nematicides (Ekalux or Theimet at 500gm per bed of 10 m × 1m.) Around 2.5 kg seed is spread uniformly over the bed, covered with straw, which should be removed when the leaves start appearing on the seedlings (Rajan). Sandal suffers from a very virulent disease caused by combined fungal and nematode infection. Seedbeds are to be sprayed with fungicide Dithane Z-78 (0.25%) once in 15 days to avoid fungal attack and 0.02% Ekalux solution once in a month to avoid nematode attack.

When seedlings have reached 4- to 6-leaf stage they are transplanted to poly bags along with a seed of "tur dal" (*Cajanus cajan*), the primary host for better growth of sandal. Seedlings are carefully removed from beds with all roots intact; roots should not be allowed to dry. Shade can be provided for a week immediately after transplantation. Watering is to be done once a day, but excess moisture is to be avoided. Host plants are to be pruned frequently, so that they do not over grow sandal and hamper its growth. Poly bags should contain soil mixture of ratio 2:1:1 (sand: soil: farmyard manure). It has been found that poly bags of 30 × 14 cm size are the best.Plantable seedlings of about 30cm height can be raised in 6-8 months' time. A well-branched seedling with a brown stem is ideal for planting in the field.

Regeneration may also be done vegetatively by wood suckers or coppicing. Tissue culture techniques for sandalwood has been reported by Lakshmi Sita and Raghava Ram (1996).

Thinning and weeding

Organic manures like, farm yard manure (FYM), vermicompost, green manure etc. may be given.

Weeding is to be done at regular intervals once in two months especially before application of manure.

Manures and pesticides

These should be used as per requirement. To prevent diseases, bio-pesticides could be prepared (either single or mixture) from Neem (kernel, seeds and leaves), Chitrakmool, Dhatura, cow's urine etc.

Irrigation

It is a rainfed crop. Young plant require watering in summer months at 15-20 days interval till they are fully established.

Diseases and pests

Ghosh and Balasundaran have reported occurrence of spike disease of sandal

in Kerala which are odd, invasive attacks by a mycoplasma type organism. With the progression of this disease, the new leaves become smaller and narrower, more pointed and fewer, until they are nothing more than sparsely scattered spikes. Of course, without leaves, there can be no life, and so the tree dies pitifully, after 2-3 years. A genetical approach for control of spike disease of sandal was suggested by Srimathi Kulkarni and Venkatesan. Plant pests of sandal (*Santalum album* Linn.) were reported by Harshkumar *et al.* (1996).

Harvesting

Sandal wood trees are harvested at the age of about 60 years. Due to over-enthusiastic harvesting, this tree is now diminishing in abundance. Traditionally, only mature trees (at least 60 years old) should be harvested. This is logical in every way. Besides allowing the entire life cycle to occur, immature trees lack a high oil concentration and the oil they do contain is of a lower quality than that of a mature tree.

Extraction technology

Sandalwood is steam or water distilled from the heartwood and roots (not the bark) . The soft wood is first removed; the hard wood is chipped and then converted into powder in a mill. The powder is soaked in water for 48 hours and then distilled by steam distillation. Distillation takes place in 48 hours. The oil is rectified by re-distillation and filtration. For determination of oil content in small sandalwood samples a new technique has been reported by Seshagiri Rao and Shankaranarayana *et al.* (1996). Traditionally, attars are made using a deg, one of the predecessors of the modern still. A deg is an ancient but still used distillation unit which delivers a superior oil in subtlety, complexity, and richness, as the distillation takes place at a very low temperature and for a long period of time. A deg distillation of sandalwood can take 10 days. To make an attar, flowers, earth or a combination of spices are placed in the main tub, and the receiver is filled with sandalwood oil, preferably itself deg is distilled. The main tub is slowly heated and the aromatic molecules are gently coaxed over to, received, and held fast in the sandalwood bed.

Yield

A mature tree yields about 60 kilos of oil. Sandalwood is considered to be a slow growing tree. It grows at the rate of 5 cm. of girth or more per year under favorable soil and moisture conditions. The heartwood formation starts around ten years of age. The following table gives an idea of growth and development:

Average heartwood formation per tree

Age (year)	Girth at breast height cm	Yield of heartwood in (kg)
1 0	1	1
2 0	2 2	4
3 0	3 3	1 0
4 0	4 4	2 0
5	5 5	3 0

Economic viability

The retail rate of heartwood at the government emporium is about ₹ 350/kg. market rate and the economics may vary. Aromatherapy accounts for only a tiny percentage of world sandalwood use, with the bulk going into the perfume and toiletries industry. The wood is also carved into religious or artistic objects and exported. A very large percentage, including bark, sawdust and waste material goes into the incense market, sometimes after having already been distilled. Less commonly, the powder is used in beauty treatments to smoothen the complexion.

Threats

Fire, grazing and most importantly exploitation of the wood for fine furniture and carving and also oil are threatening the species. Smuggling has assumed alarming proportions. Despite the strict laws in India governing the sandalwood harvest, poaching of the new saplings that spring up still takes place during the monsoon regularly. Also, even though *Santalum album* in India fruits twice a year, in April-May are often destroyed in seasonal forest fires.

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Aromatic Marigold

(*Tagetes minuta* Linn.)

Aromatic marigold (Family Compositae) is also called Genda in India and in other countries Chinchilla, Chiquilla, Chilca, Zuico, Suico, Anisillo.

Origin and distribution

It is native to the temperate grasslands and south America, including the countries of Argentina, Chile, Bolivia, Peru, and in the Chaco region of Paraguay (McVaugh, 1943; Reiche, 1903; Perkins, 1912; Herrera, 1941; Espinar, 1967). It is used as essential oil, a condiment, as a refreshing beverage, and for medicinal purposes (Manfred, 1947; Freise, 1934; Parodi, 1959; Thays, 1910). In each case flowers, leaves and stems are utilized.*Tagetus minuta* is often found growing in disturbed areas during early successional stages. This affinity for disturbed sites has allowed the species to colonize many areas

Aromatic Marigold

around the world. Since the time of the Spanish Conquest, it has been introduced into Europe (Jordano and Ocana, 1955), Asia (Cherpanov, 1981), Africa (Hillard, 1977), Madagascar (Humbert, 1923), India (Rao *et al.* 1988), Australia (Webb, 1948), and Hawaii (Hosaka, 1954).

Description of the plant

Tagetes minuta is an erect annual herb reaching 1 to 2 m height. Leaves are slightly glossy green, and are pinnately dissected into 4 to 6 pairs of pinnae. Leaf margins are finely serrate. The undersurface of the leaves bear a number of small, punctate, multicellular glands, orangish in colour, which exude a licorice-like aroma when ruptured. Glands may also be found on the stems and involucre bracts. Four or five fused involucre bracts surround each head. There are typically 3 to 5 yellow-orange ray florets, and 10 to 15 yellow-orange disk florets per capitula. The heads are small, 10 to 15 mm long, and including ray florets, 10 to 20 mm in diameter. The heads are borne in a clustered panicle of 20 to 80 capitula. The dark brown achenes are 10 to 12 mm long, with a pappus of 1 to 4 tiny scales and 0 to 2 retrosely serrulate awns which are 1 to 3 mm long. *Tagetes minuta* is often referred to as a weed. Cabrera (1971) states that ".... Spegazzini mentions that this plant is a common weed of cultivation in the lower Rio Negro Valley...." Spegazzini and Cabrera appear to not understand the native outlook on "weeds." The farmers view the "weeds" as a second crop. Many of the Latin American farmers who do not practice industrialized agriculture will leave volunteer plants of *Tagetes minuta* in their fields. This second crop is beneficial in several ways: first, rapid growth of *T. minuta* quickly shades out other plant species that may be of less use to the farmer, second, it can be harvested for personal use, or for sale in city markets, and third, has been reported to aid in the retention of humidity in the field (Jimenez-Osornio, 1991).

Cultivation technology

Tagetes minuta grows readily from seed sown directly into the soil (B.M. Lawrence: unpublished report). Plant height varies with conditions. Based on studies of herbarium material from the University of Texas and Lundell Collection; Field Museum, Chicago; New York Botanic Garden; University of Arizona; Michigan State University; and California Academy of Sciences; single, open grown plants range from 0.5 to 1 m tall, yet when grown in dense stands, a height of 2 m can be reached. *Tagetes minuta* thrives in full sun. Competition for sunlight can lead to tall spindly plants with a low biomass. Higher biomass is attained from spacing the plants 1 m apart, and removal of the apical meristem at 30 days to stimulate branc hing. Meristem removal may be done mechanically.

Plant protection

Pests do not appear to be a significant problem with *Tagetes minuta* in field culture. Red spider mite and root knot nematode are often serious pests on cultivated forms of *Tagetes erecta* Linn. (Steiner, 1941). In field studies in Austin, Texas, these pests have not been found on *T. minuta* despite the presence of large populations of these pests on *T. erecta* at the same site.

Harvesting

Harvest for use as a beverage or condiment is done manually by cutting the main stem at ground level, since the entire above-ground portion of the plant is considered useful. Plants over 1 m have individual branches cut off and dried. The plant material is folded and tied into bundles using twine, grasses, or a pliable branch of *T. minuta* . The bundles are hung in a dry place, out of direct sunlight, to dry. Commercial hand harvesting is feasible due to low labor rates in South American countries. Since the whole plant is utilized, mechanical harvesting could be a viable option, and is used in essential oil production.

Chemistry

It is rich in many secondary compounds, including acyclic, monocyclic and bicyclic monoterpenes, sesquiterpenes, flavonoids, thiophenes, and aromatics (Rodriguez and Mabry, 1977).

Aromatic and medicinal uses

- *Tagetes minuta* is commercially grown and harvested for its essential oils which are used in the flavor and perfume industry as "Tagetes Oil." The oil is used in perfumes, and as a flavor component in most major food products, including cola beverages, alcoholic beverages, frozen dairy desserts, candy, baked goods, gelatins, puddings, condiments, and relishes (Leung, 1980). Brazil is one major producer of *T. minuta* for Tagetes Oil (Craveiro *et al.* 1988). Worldwide production of the oil is around 1.8 tonnes.
- There is evidence that the secondary compounds in *Tagetes* are effective deterrents of numerous organisms, including fungi (Chan *et al.* 1975), fungi pathenogenic on humans (Camm *et al.* 1975), bacteria (Grover and Rao, 1978), round worms in general (Loewe, 1974), trematodes (Graham *et al.* 1980), nematodes (Grainge and Ahmed, 1988), and numerous insect pests through several different mechanisms (Jacobsen, 1990; Saxena and Koul, 1982; Maradufu *et al.* 1978; Saxena and Srivastava, 1973).
- Many closely related plant secondary compounds have demonstrated medicinal value in humans (Kennewell, 1990; Korolkovas and

Burckhalter, 1976). *In vivo* human studies of the secondary compounds of *T. minuta* have not been reported, although other *Tagetes* species have been proven medically safe and efficacious (Caceres *et al.* 1987).

- Hethelyi *et al.* (1986), determined anti-microbial activity of five secondary compounds in *Tagetes minuta*; beta-ocimene, dihydrotagetone, tagetone, (Z)-ocimenone, and (E)-ocimenone. When tested on 40 strains of bacteria and fungi, the essential oil of *T. minuta* had a 100% inhibitory effect on Gram-positive bacteria, a 95% inhibitory effect on Gram-negative bacteria, and a 100% inhibitory effect on fungi.
- Hudson (1990) tested the many different secondary compounds for anti-viral activity, and determined that thiophenes demonstrated the greatest anti-viral action at the lowest doses, and with the least toxicity overall. Of the thiophenes, molecules with two or more thiophene units showed the highest activity. In all cases, the best success was against viruses with envelopes. Hudson tested 32 thiophenes, evaluated their efficacy and determined the 10 most effective ones. Atkinson *et al*(1964) first reported the thiophenes found in *Tagetes minuta*. A comparison of Atkinson's results to those of Hudson, shows that 7 of the 10 most effective anti-viral thiophenes are found in *Tagetes minuta*.
- The work of Hethelyi *et al.* (1986) and that of Hudson (1990) indicate that the use of *Tagetes minuta* as a medicinal beverage by indigenous people may have a valid biological basis, although *in vivo* work has not been published. Further work is warranted, and could be used to aid in the marketing of herbal products of *Tagetes minuta*.
- Chandhoke and Ghatak (1969), working with experimental animals, determined that the oil of *Tagetes minuta* has hypotensive, bronchodilatory, spazmolytic, anti-inflammatory, and tranquilizing properties. These actions are in accordance with the reported folk use of the beverage as a medical decoction. Given that generations of South Americans have used *T. minuta* as a beverage and condiment, it seems that use in moderation causes no ill effects.
- A beverage is prepared from *Tagetes minuta* by steeping a "half-handful" of the dried plant in hot water for 3 to 5 minutes. The beverage may be consumed warm or cooled, and may be sweetened to individual taste (Neher, 1968).
- For medicinal use, a decoction made by steeping a "double handful" of the dried plant in boiling water for 3 to 5 minutes is used as a remedy for the common cold; including upper and lower respiratory tract inflammations, and for digestive system complaints; stomach upset, diaorrhea, and liver ailments. The decoction is consumed warm, and may be sweetened to individual taste (Neher, 1968; Parodi, 1959; Cavanilles, 1802).

- *Tagetes minuta* is used as a condiment in Chile and Argentina. It is popular in rice dishes and as a flavoring in stews. In northern Chile *suico* is so highly prized that many people actively collect wild populations to dry a sufficient supply to last the winter (Soule, 1993).
- The New World people have been using *Tagetes minuta* as a flavorful beverage, a medicinal tea, and a condiment since pre-contact times (Rees, 1817). The local names vary by region, most commonly found in the literature as; *chinchilla*, *chiquilla*, *chilca*, *zuico*, *suico*, or the Spanish term *anisillo*.

Scope of future development

- *Tagetes minuta* can be used for a hot or cold refreshing beverage. In taste tests at the University of Texas, subjects reported that the flavor is slightly sweet and anise-like and mild.
- Currently, many nations are actively seeking alternative cash crops to replace cultivation of illegal drug plants. Several species of Tagetes have been investigated, including *Tagetes minuta* (Bernal and Correa, 1991; Arora, 1989). *Tagetes minuta* as a herbal beverage has the potential to become a new crop for many of the hither-to drug growing areas.

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Mexican vanilla

(*Vanilla planifolia* Jacks. ex Andrews)

Mexican vanilla (*Orchidaceae*) is also known as Vanilla Pod, Vanilla Vine,Vanilla Beans and Vanilla.

Origin and distribution of vanilla

Mexican vanilla is most expensive spice traded in international market. It is the source of natural vanillin a major flavoring compound used in ice cream and other soft drink preparations. The vanilla beans contain 1.2 to 2.9% vanillin. Commercially used vanilla bean is obtained from different species of Vanilla eg. *Vanilla planifolia* Andrews (Mexican vanilla), *Vanilla pompona* Schiede (West Indian Vanilla) and *Vanilla tahitiensis* J M Moore (Tahiti Vanilla). The most important is *Vanilla planifolia* Andrews (Mexican Vanilla). The vanilla is a Spanish word which means a small pod. This species is cultivated in

Vanilla

Bourbon, Indonesia, Guatemala, Costa Rica, Uganda, China, India, Papua New Guinea, Tonga, Fiji, Tahiti and Philippines. In India it is mainly grown in Kerala, Karnataka, Tamil Nadu and to some extent in Karnataka. Vanilla import is mainly done by United States, France and Germany. In the world there are about 36.000 hectares under vanilla and the world production is 4285 tonnes/year. In India, production of cured vanilla beans is 3 to 5 tonnes/ year. Until 19th century Mexico had the monopoly of growing vanilla. But after wards Madagascar and Indonesia grows the majority of the world's crop. Madagascar an island of Africa is the largest producer of vanilla beans in the world and that vanilla is known as Madagascar (Bourbon) vanilla. The word Bourbon means the Bourbon islands such as Madagascar, Comoro, Seychelles, and Reunion. Madagascar (Bourbon) vanilla is considered to be the highest quality available. It is described as having creamy, sweet, smooth, mellow flavoured pulp. Indonesia is the second largest producer of vanilla which is astringent, woody and phenolic. Madagascar (Bourbon) and Indonesia produce about 50% of the world's vanilla crop.

Mexico, where vanilla orchid originated , grows only a small percentage of the world production. Mexican vanilla is described as creamy, sweet, smooth and spicy . Tahiti vanilla grown from a different species is flowery, fruity, anisic and smooth. Vanilla is a labour intensive crop. That is why it is so expensive.

Plant description

It is a climber with succulent leaves, long succulent green stem, greenish white aerial roots growing from opposite side of leaves by which it clings to support. Flowers have velamen which prevent pollination. Fruits are known as beans or pods.

Chemical constituents

Important chemical constituents are: vanillin – phenollic aldehyde, benzoic acid, vanillic acid, formalic ester and anisic alcohol .

Cultivation technology of vanilla

Vanilla is propagated throughvegetative means by stem cuttings. Strong, healthy and actively growing young vines are used as planting material. If longer cuttings are planted they will grow faster and come to flowering early. Usually, one meter cuttings are preferred as planting material. Less than 50 cm length cutting should not be used for direct planting in field. Vines once flowered and yielded should not be used as planting material as they will not sprout and establish. The planting material collected may be cut into pieces of ½ to 1 meter length depending on availability of vines.

Vanilla rooted cuttings raised in polythene bags are also used as plating material. 6″ × 6″ polythene bags filled with potting mixture of 1:1:1. (soil,

farm yard manure and sand). Two cuttings from young vines which are healthy and disease free, can be planted in the poly bags during January–February and kept under a tree or under shade of pandal and watered regularly. The rooted plants will be ready for planting during June-July. It is an easy method of propagation.

Source of vanilla cuttings

- Vanilla farmers are the main source of planting materials.
- Some farmers associations also supply the planting materials through its members.
- Vanilla rooted cuttings are also available in spice board's departmental nurseries.
- There are some private nurseries meeting the planting material demands.

Tissue culture technique for vanilla propagation

Traditionally vanilla is propagated by stem cutting which is reportedly uneconomical as it involves sacrifices of almost whole plant because its growth is monopodial in nature. Therefore, tissue culture technique has emerged more or less as alternative source for large scale production of planting material within a short span of time. The technique is described below:

Source plant maintenance and collection of ex-plant.

Actively growing shoot from healthy, disease free, high yielding plant should be maintained properly in protected area. Give regular prophylactic foliar spray with 0.2% Bavistin or indofil once in two weeks.

Nodal segment 2-3 cm long should be collected from second or third node to fifth or sixth nodes on actively growing shoot. The best time to do it is November to May, August to September or when there is no regular rain. If the explants are taken during rainy season some loss of primary culture is likely to occur due to high rate of contamination.

Initiation of asceptic culture/primary culture establishment

(a) *Surface sterilization and preparation of ex-plant:* Nodal segments (explants) should be thoroughly washed in mild detergent solution before subjecting them to surface sterilization procedures. Surface sterilization is carried out by suspending the explant in 0.08% mercuric chloride solution for 12 minutes preferably under vacuum. Two-three drops of surfactants such as Tween 20 or Teepol should be added to the sterilant. If vacuum can not be provided swirl the content well during the treatment. Sterilant is then drained off and the explant washed thoroughly with several changes of sterile distilled water. Subsequently the explants contained in sterile blotting papers, trimmed and blot dried prior to inoculation to nutrient medium.

(b) *Culture medium, primary culture initiation and establishment:* Murashhige and Skoog (1962) medium or Knudson (1946) medium + BAP 1 mg/l, AA .0.1mg/l; D. Biotin 0.1 mg/l, Ca pantothenate 0.1mg/l ; Sucrose 3% and Agar 0.65 gm/l· pH of the medium should be 5.8. The explant should be inoculated on to this medium followed by incubation under 18 hour photoperiod (1000 lux) at 25 ± 20°C. Axillary bud starts sprouting by the second week of culture initiation.

Shoot multiplication

Composition of medium is the same as that for culture establishment . Subcultures can be initiated after 30-35 days of initial inoculation of primary culture - a length of more than one centimeter. For this the new sprouts should be separated from the original explant by razor edge scalpel and transferred to fresh medium for further multiplication. Further subculture can be carried out at 40-45 days interval on fresh medium of the same composition.

Shoot elongation and rooting

Elongation and rooting of shoots can be facilitated in a single medium in case of vanilla. In this case composition of medium is different as given below.

MS/KC + 0.1 mg/l KN; 0.1 mg/l NAA; Sucrose 2% and Agar 0.65% . Shoot initiate elongation and strike roots within 20–30 days and within 50–60 days attain 6-8 inches length of shoot with 3 to 4 leaves and 2 to 3 roots.

Transfer to pots, hardening and acclimatization

The plantlets (8 to 10 cm long) are removed carefully from culture vessels and gently washed under tap water to remove agar. It is followed by suspension of plantlets in 0.1% bavistine solution for 15 minutes. The plantlets are then transferred to micropots containing soil rite or pure river sand and watered immediately. Subsequently they are covered with clear plastic and kept under green house condition. Regular sprays of water have to be provided. Alternatively the plantlets are directly placed in mist chamber where intermittent mist facility is available. If found necessary the plantlets should be sprayed with Knop's or Hoaglands solution once in a week. Thereafter they are progressively hardened by gradually reducing humidity and shade for 4-5 weeks.

After hardening the plantlets should be transferred to potting mixture and allowed to get acclimatized in the green house or nursery for two months or when the plantlets attain a length of atleast one foot in length.

Based on the actual cost involved in the production of 3,560 plantlets of vanilla through tissue culture, cost of production of one plantlet was found to be ₹ 5.64.

Biotechnological firms selling vanilla plants

1. Biotechnology Division,
   M/S Indo American Hybrid Seeds,
   17th Cross, 2nd A Main,
   Banasankari II nd Stage, Bengaluru 560 070.

2. Biotechnology Division,
   M/S AVT & Co.,
   Plot No 10 & 11, CEPZ, Cochin 682 030.

3. M/S Growmore Biotech Ltd.,
   41 – B Sipcot phase-II,
   Hosur, Tamil Nadu 635 109.

4. M/S A G Biotech,
   Bachupalli Post,
   Qutbhallapur, Hyderabad 500 072.

Improved planting technology of vanilla

Vanilla vines are planted close to the base of the support tree. Three or four based nodes from where leaves are removed are laid in the loose soil and gently pressed. The top end of the vine is tied to the support tree enabling the vine to grow. Base of the plant may be mulched with organic material like coconut husk, straw, leaves etc. The ideal time for planting is when the soil is moist but rainy season should be avoided. Planting in May–June or August–September depending on intensity of rain will be ideal. It takes 4 to 8 weeks to strike roots and to show initial sign of growth from any of the leaf axil. Rooting will be early in younger vines.

Provide shade to vanilla

Vanilla performs well under 50% shade condition. So the shade should be regulated to provide the required amount of shade. Overcrowding of plants should be avoided and proper aeration should be provided for better growth and to avoid diseases.

Application of manure

Vanilla needs lot of organic matter for proper growth. Decomposed cattle dung, compost, leaf manure etc. may be added. A thick layer of organic debris around the plant helps to retain moisture and aeration and gives a loose soil structure for the roots to spread.

Cultural operations in vanilla

As the roots are very tender confining to surface layer of soil , it should not be damaged by any cultural operation. Damaging of the root zone by poultry should be avoided. Timely irrigation should be provided especially in early years of growth. Weekly irrigation of 2–3 litres of water/plant is enough. For older yielding vines also irrigation is required. Weed growth around the plant and support tree should be removed from time to time. The weeds can be used to mulch plant.

Growth of vanilla plants

The vines should be allowed to grow upwards on the support tree and if necessary the vines should be tied to the support tree. The vines may be allowed to grow to a height of 1.20 to 1.50 meter and allowed to hang down. Such branches should be brought back to the ground. Later it is brought up by providing support. Then the vines are trailed up and down for the first two years so that the plant produces enough vines to form bearing branches. The bearing branches are not allowed to touch the ground and before that it is pruned to enable flowering and fruiting.

Flowering of vanilla

Normally flowering starts in the third year in a healthy plant. Generally only one time flowering is noticed in a year. Inflorescence is formed in the axil of leaves on the previous years growth. Pruning the tip of the vines and stopping irrigation helps in profuse flowering. Depending on the elevation flowering occurs in December to March and it takes 45 days from initiation of inflorescence to flowering.

Vanilla support tree management and pruning

The support tree should be allowed to form branches in different directions at a height of 150 to 200 cm above the ground and it should be pruned to provide the required shade. More number of branches will be useful for the growth of vines.

Pruning of support tree should be done before onset of heavy rains to allow in more sunlight. Another light pruning should be done just before the beans are harvested to facilitate their maturity and initiate flower bud formation for the next crop.

Hand pollination in vanilla

Natural pollination in vanilla is difficult as stigma is prevented from coming into contact with anther by a flop like projection called “rostellum”. Therefore hand pollination is essential for production of beans. This can be done by holding a tooth pick or pointed bamboo splinter in the right hand to push back

the rostellum and pressing the pollen sac with the left thumb to smear pollen grains to the stigma. Artificial pollination should be done on the same day of flower opening, otherwise unfertilized flowers drop off in a day or two. Pollination should be done in the morning hours from 6 am to 12 noon. A skilled worker can pollinate 1,500 to 2,000 flowers in a day. Generally one flower opens in an inflorescence in a day and thus the inflorescence may be in flower for nearly 3 weeks.

It should be ensured that maximum pollen should fall on the stigma. After pollination and fertilization the beans start developing quickly and obtain full size within 5 to 6 weeks. The unfertilized flower that failed in pollination will fall on next day. The beans take 9 to 11 months to attain maturity.

Plant protection

Vanilla faces threat from following few diseases:

Fusarium Wilt : It is caused by the fungus *Fusarium oxysporum S*chlecht. The disease is more prevalent in younger plantation especially during monsoon. The infection starts at leaf axil and spreads to inter node region resulting in rotting and drying of the stem above the part of infection. The fungus also causes leaf rot on the plant. Regarding the measures to be undertaken to keep the malady under check, it is advised to remove and burn the diseased and dead tissues and provide adequate drainage to the plantation. Spraying and drenching carbendazim 0.1% against the disease is quite effective. Addition of organics which encourage growth of antagonistic microflora also reduces intensity of the disease. Spray of 1% Bordeaux mixture also helps in controlling the disease.

Phytopthora rot: It is caused by the fungus *Phytophthora meadii*. It causes rotting of beans, leaves and stem. It is more severe during monsoon especially in shaded and poorly drained soils. Spray 1% Bordeaux mixture and drenching the soil with copper oxychloride control this disease. Uproot the diseased vines with root system cut into pieces and burn. Do not use the same knife for cutting the diseased and healthy vines. Do not touch the healthy vine after touching diseased vine without cleaning the hands. Do not use any plant material taken from diseased plants.

Harvesting of vanilla

Stage of harvest is one of the important factors to determine the quality of the processed beans. Time required for the fruits to mature from the date of pollination is 9 to 10 months. The beans should be harvested when they are just ripe and at this stage the blossom-end of the fruit turn yellow. It is necessary to harvest the beans at the right time because immature ones produce an inferior product and if picked too late they will split from the blossom end. The split beans are not only difficult to process but are also considered inferior in quality

after processing. During the harvest period, the vanilla plantation should be visited every day so that the beans ready for harvest are gathered by side ways pressure of the thumb at the base or cutting with a sharp knife. Vanilla harvesting season in Madagascar extend from June to early October . About 60 to 70 beans of 15 to 18 cm in length are found to make one kilogram green beans.

When the beans are harvested they have neither flavor nor fragrance due to absence of vanillin at that time. Beans develop the properties after lengthy process of curing. Due to enzymatic action several glucosides, various aldehydes, aromatic esters, protocatechic acid, benzoic acid, vanillic acid and anisic alcohol are also formed and all these compounds together give the fragrance of natural vanilla. Many curing process have been developed in various vanilla growing countries to meet the quality requirements of vanilla market.

Curing technique of vanilla beans

The curing of vanilla beans or pods has been defined as their controlled ripening (Lionnett, 1959). It is a process of alternatively sweating and drying beans until they loose most of their moisture - as much as 80% in curing Mexican beans (Correl, 1953). Curing is the extremely important stage in production because during this process they undergo the enzymatic reactions responsible for characteristic flavor of vanilla.

Traditional curing methods

A number of procedures have been evolved for curing of vanilla. They are all characterized by four phases (Thesdose, 1972).

- *Killing or wilting*: This stops further vegetative development in the fresh beans and initiates enzymatic reactions responsible for the production of aroma and flavour. Killing is indicated by development of brown colour of the bean.
- *Sweetening*: This involves raising temperature of the killed beans to promote the desired enzymatic reactions and to provoke rapid drying to prevent harmful fermentations. During this operation the beans acquire a deeper brown colouration and become quite supple, and the development of an aroma becomes perceptible.
- *Slow drying*: The third stage entails slow drying at ambient temperature, usually in shade, until the beans have reached about one third of their original weight. During this stage production of different fragrances takes place.
- *Conditioning*: In this final stage, the beans are stored in closed boxes for three months or longer to permit full development of the desired aroma and flavour.

Bourbon method of curing

The most important curing method is Bourbon method. Bourbon vanilla is considered to be the best quality vanilla in the world trade. Bourbon method for curing of vanilla beans was developed by Purseglove *et al.* (1988). It has following four stages

Stage 1: On arrival at curing factory, the beans are sorted according to degree of maturity, size and split and unsplit types. Batches of beans, weighting 24-30 kg are loaded into open cylindrical basket, which are then plunged into container full of hot water heated to 63-65°C over a fire. Batches of beans of top 3 qualities are immersed for 2 to 3 minutes, while smaller and split beans are treated for less then 2 minutes. This is called scalding . The warm beans are rapidly drained, wrapped in a dark brown cotton cloth and are placed in a cloth lined sweating box. The beans acquire dark brown colour in 24 hours.

Stage 2: Next day the vanilla is taken out of the sweating box and inspected to separate those which have not been properly killed. The properly killed beans are spread on dark, coloured cotton covers and placed on 'dryers' which are slotted supports of bamboo placed 70 cm above ground. This process is known as 'sunning'. The exposure lasts for a total of 2 to 3 hours. After this period, the edges of the covers are folded over the beans and kept as such to retain their heat as much as possible. The sunning area must be sited on a dry, easily drained ground and at some distance from road in order to avoid contamination from dust. These operations are repeated for 6 to 8 days during which, the beans lose moisture and become supple.

Stage 3: This stage involves slow drying in the shade for period of 2 to 3 months. The beans are spread on racks , mounted on supports and are spaced 12 cm apart in a well ventilated room. During this slow drying the evolution of fragrance continues. Repeated sorting enables picking of beans which have become sufficiently dried retaining desired moisture content.

Stage 4: Conditioning of the beans takes about 3 months for completion.

Modified bourbon method for curing of vanilla

Bourbon vanilla is considered to be the best quality vanilla in the world trade, hence this method of processing has been suitably modified and followed in India. Modified bourbon method for vanilla curing also involves following 4 steps explained above, but the duration taken for different steps is different and the temperature, relative humidity requirements etc. are quantified.

Step 1: *Killing:* The beans are sorted according to size. Sorted beans

are put in either a bamboo basket or gunny bag and immersed in hot water for scalding. Bigger beans are dipped for 5 minutes and smaller beans for 3 minutes. The water is rapidly drained and the beans are placed in woolen lined wooden box. Scalding is done at a temperature of 68°C. Afterwards it is brought down to about 5°C. Temperature of water is a critical factor as higher temperature deactivates the enzymes responsible for conversion of vanillin and other flavour inducing components. Properly killed beans turn brown in colour within 24 hours. The scalding helps in disruption of cell structure and release of enzymes. Care should be taken not to attempt scalding at temperature more than 70°C.

Step 2: *Sweating*: It is the most critical stage in curing of vanilla. Enzymes responsible for conversion of vanillin and related compounds are most active in this phase. The killed beans are spread on woolen cloth in sun and allowed to gather temperature. When the temperature of the beans attains about 55°C (too hot to hold with bare hands). They are wrapped in woolen clothing and kept in sun for a hour more and then stored in woollen lined wooden box for sweating for rest of the day. Sunning may take one-and-a-half hour to three hours depending on location and also part of the day. It is observed that exposing the beans to sun on a raised platform about one meter above the ground is better than exposing them directly on the ground. It is better to allow temperature to rise slowly than expose the beans suddenly during hottest part of the day. Process of sunning and sweating have to be continued for 8 to 10 days.

At the end of sweating period the beans attain chocolate brown colour, become very supple and loose 40–50% moisture. Weight of the beans is reduced by 50–60%. Arana (1994) compared traditional sun drying/sweating procedure with an electric oven chamber set at 45°C in which the humidity was kept high. Over-sweating and drying was found to have advantage in that the incidence of mould was less, a shorter time was required and the procedure was less expensive.

Step 3: *Slow drying*: This step helps in removing the excess moisture and bringing it down to the desired level. At end of sweating, moisture comes down to 50 to 60% . It has to be brought down to 25 to 30%. It is achieved by spreading the beans on wooden racks in a well-ventilated room at ambient temperature.

Moisture is lost slowly, the beans become deep chocolate brown in colour. The beans have to be observed regularly during this stage to check for attack of mould. Due to loss of moisture weight of beans comes down to 70 to 75 % less at the end. Vanillin and related compounds continue to be formed during this stage. Slow drying process may take 10 to 15 days.

Step 4: *Conditioning:* Conditioning is done after the moisture in the processed bear is brought to desired level by slow drying process. The beans are bundled according to the size and into bundle of known weight. These are wrapped in butter paper and stored in airtight containers under ambient temperature for about 2 to 3 months. Various biochemical reactions such as esterification, etherification, oxidative degradation etc. takes place during conditioning and volatile aroma compounds are formed. At conditioning stage the beans have to be examined carefully to avoid mould or mite damage. When stored at low temperature vanillin crystals are formed on the beans which is called frosting. Jones and Vincente (1949) have reported that 35 to 45°C temperature was found to accelerate conditioning and the product had superior aroma compared to those conditioned at lower temperature.

Uses of vanilla

Vanilla is one of the most popular food flavour in ice cream, backing and chocolate industries in United States and many other countries. It is also used in flavouring of beverage, cakes, confectionaries, custards, pudding and also in manufacture of soaps , perfumes and pharmaceuticals . Vanilla is generally used in the form of an extract from the cured beans. In the manufacture of chocolate the beans are usually ground finely with sugar and included with chocolate.

Quality parameters of cured vanilla

According to Purseglove *et al.* (1988), the primary quality requirement for cured vanilla beans is the aroma/flavour character. Factor of significance in quality assessment are the general appearance, flexibility, the length and vanillin content. The relative importance of these quality attributes is dependent upon the intended end use of the cured beans.

Top quality beans are long, flirty, supple, very dark brown to black in colour, somewhat oily appearance, strongly aromatic and free from scars and blemishes. Low quality beans are usually hard, dry, thin, brown or reddish brown in colour and posses a poor aroma.

Beans with an average moisture content of 32% has well developed, pleasant

aroma and high degree of flexibility (Arana and Kevorkian, 1943). These scientists also found that 50 to 54% moisture tended to have a slightly fermented aroma and were less pleasant. The moisture content of top grade beans is 30 to 40%. It may be as little as 10% in lower grades.

Grading of vanilla

Properly cured and dried vanilla beans are dark brown and supple enough to be twisted around the finger without rupturing. Before being packed they are smoothned and straightened by being drawn repeatedly through the fingers. This massaging helps to bring out some of the oil which exudes during fermentation and gives the beans their characteristic lustiness.

If vanilla beans are not used then they are subjected to attack from mildew. Once the beans permeated with the attack of mold it is practically impossible to eliminate it and the value of the beans is much reduced. The mouldy portion is cut away and the remainder of beans known as "cuts" is sold to perfumery and soap industries etc. Not all the "cuts" are the result of mould. They also consist of beans of inferior quality.

Those beans which have split during the curing process are also set apart to be sold as "split". Beans with more than 36% moisture are considered to be subjected to moulding.

The beans are classified into several groups primarily as to quality and length, before being packed. The best are without defects being oily, smooth, strongly aromatic and essentially black or very dark brown. Usually six kilogram of green beans produce one kg of commercial vanilla. Second class beans are somewhat defective in that they are over dried, less aromatic, have a rough exterior and are somewhat reddish. Split beans, which have lost some of their perfume comprise the third class.

Geographic classification of vanilla

Vanilla beans of commerce have been divided into 5 principal geographic types : 1. Mexican, 2. Bourbon, 3. South American (including west Indian vanilla and pompona), 4. Tahite and 5. Java. Beans were originally from islands of Reunion (Bourbon) only, but they now include all beans grown in Madagascar, Comoros , Seychelles islands and other countries. South American beans are grown mainly in French West Indies. Tahiti beans are an inferior vanilla grown in the French group of Society Islands. The crop is large in Tahiti but the beans have less flavour. Java beans are grown in Indonesia.

Value addition in vanilla

Various value added forms of vanilla beans such as vanillin extract, vanillin tincture, vanillin oleorasin, vanilla powder, vanilla paste, perfumery vanilla tincture, vanilla absolute etc. are available in national and international market.

Vanilla extract is the hydro alcoholic solution containing the extracted aroma and flavour principles of vanilla beans and may also contain added sweetening/ thickening agents such as sugar and glycrene. It is prepared by direct extraction or by dilution of concentrated vanilla extract known as vanilla oleoresin. Another product, vanilla tincture is prepared by maceration of one part of vanilla beans by weight to ten parts of aqueous alcohol by volume and added sugar and 38 percent of ethyl alcohol. This extract is mainly used for pharmaceutical purpose. Vanilla oleoresin is the semi-solid concentrate obtained by complete removal of solvent from vanilla extract. For the preparation of oleoresin aqueous isopropanol is generally used. Vanilla powder is the pure powdered vanilla or a mixture of vanilla powder or vanilla oleoresin with sugar, starch or gum acacia. Perfumery vanilla tincture is prepared by maceration of vanilla beans with perfumery alcohol. It is used for perfumery application.

Another value added product of vanilla beans is the vanilla absolute. It is prepared by direct alcohol extraction of vanilla beans followed by alcohol washing of oleoresin prepared by extraction with hydrocarbon solvents like hexane etc. It is the most concentrated form of the vanilla aroma. It is often used in perfumes and other aroma based products. Because it is so expensive, most soaps and scented merchandise are made from synthetic vanillin. Vanilla absolute is used in very valuable end product in small quantities, often mixed with other fragrances in perfumes.

Synthetic vanilla

It is an interesting fact that 97% of vanillin used as a flavour and fragrances is synthetic. It synthesized from other compounds, such as eugenol (major fraction of clove oil) and as a byproduct from the break down of lignin in the manufacture of paper from wood pulp. Extracts of vanillin derived from sources other than vanilla beans are usually labeled "imitation vanilla". Vanilla bean extract is more expensive, but has a better flavour than imitation vanilla. One part of vanillin is equivalent to 400 parts of cured vanilla beans.

Vanillin (4-hydroxy-3-methoxy benzaldehyde) is classified chemically as a phenolic aldehyde. In its pure form, it is a white/slightly yellow needle shaped solid at room temperature with a melting point 80-81°C. Vanillin is not very soluble in water, only one gram of vanillin will dissolve in 100 ml of water at room temperature; however it is freely soluble in organic solvents like ethyl alcohol, ether, chloroform, glacial acetic acid, carbon disulphide etc.

The synthetic vanillin is identical to natural vanillin in all respects. Lignin derived vanillin is cheaper and offers an inexpensive product by substituting synthetic vanillin. Whether it originated in the bean or is synthesized from lignin, standard chemical analysis indicates the identity, and

quantity of the compound. But inspecting the carbon atoms in the vanillin with a technique called Stable Isotope Ratio Analysis (SIRA) can identity this adulteration.

SIRA is based on the fact that not all carbon atoms have the same mass of the carbon atoms found in nature, 98.9% have a mass number of 12, a 1.1% have a mass number of 13. However, the ratio of these isotopes is slightly different for natural vanillin than for synthetic vanillin. The synthetic vanillin is enriched in C^{12} isotope. This happens because of difference in biochemistry of the vanilla orchid. The vanilla orchid carries on photosynthesis by the crassulacean pathway. Most plants, however, including trees, use the calvin pathway, which involve a great number of chemical reactions. Because C^{13} is heavier than C^{12}, C^{13} reacts more slowly. Not as much gets through each of the chemical reactions in photosynthesis. This results in a lower percentage of C^{13} in lignin than in synthetic vanillin. However the unscrupulous producers have also evolved methods to adjust the C^{13} / C^{12} ratio in the synthetic product to more closely match that of natural vanillin. The easiest way adopted is the removal of the methoxy group containing C^{12} and the replacement with another methoxy group containing C^{13}. This could also be identified by removing the methoxy group and testing for the presence of C^{13} using mass spectrometry. Although the advances in chemical synthesis are great, natural vanilla will always be one of those delightful spices.

Yield and economics of vanilla cultivation

Yield depends on age of vines and method of cultivation. Normally it starts yielding from third year and it increases till the fifth year. Afterwards yield can be maintained by appropriate pruning, cultural practices, shade regulation, plant protection etc. Based on yield level, replating could be done by 10 years.

With reasonable management, normal yield of 1500 kg to 3000 kg of green beans or 300 to 600 kg of cured beans per year per acre is obtained . Average price of unprocessed good quality green beans ranges between ₹ 600 to 900 per kilogram. Processed beans fetch ₹ 7,500 to 10,000 per kilogram in international market.

As technology in India for vanilla is not well developed. For large scale processing many farmers are satisfied with just growing and selling the green beans. Considering the fact that cost of production is rather average, no shortage of planting materiel and profit is attractive, farmers are finding vanilla cultivation very attractive specially as intercrop with other perennial crop in their homesteads.

Scope of future development of vanilla

- Development of high yielding varieties resistant to diseases and pests.
- Further improvement on curing technology

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The book – Medicinal and Aromatic Plants – presents an integrated account of contemporary status of agricultural research and production technology for profitable cultivation of forty-one medicinal and aromatic plants as commercial crops in India.

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